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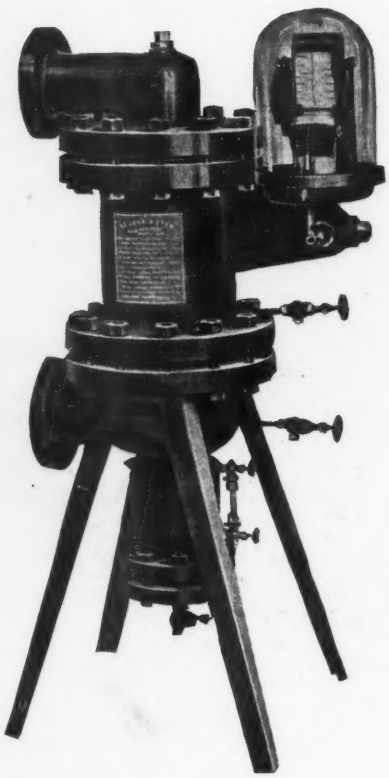
Vol. XVI JANUARY, 1911 No. 1



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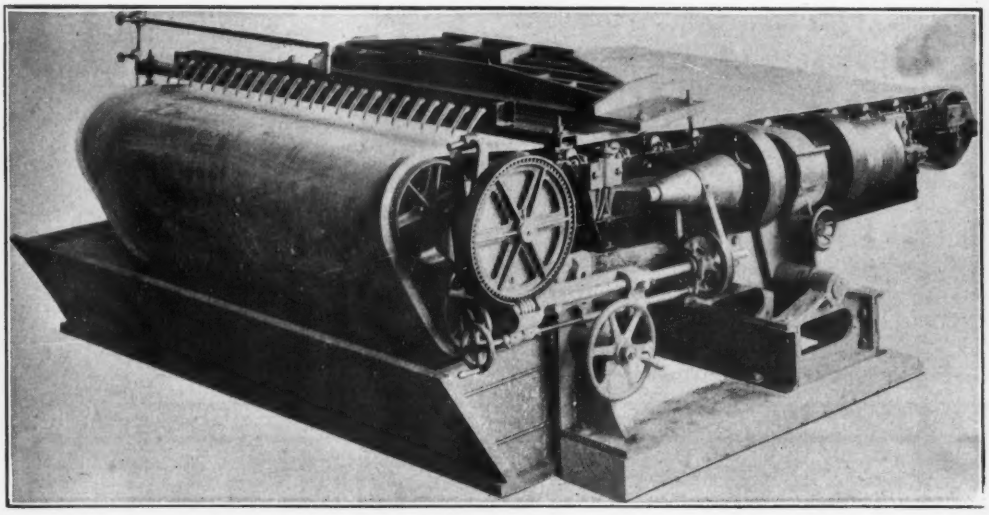

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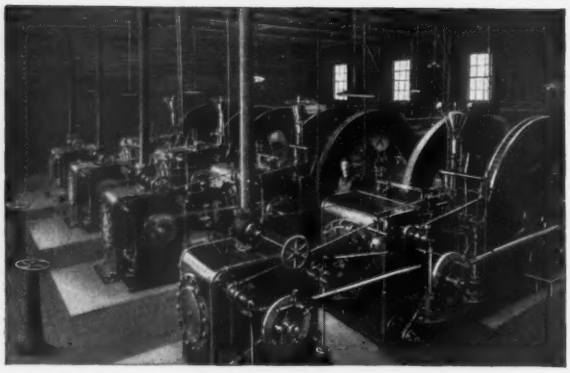

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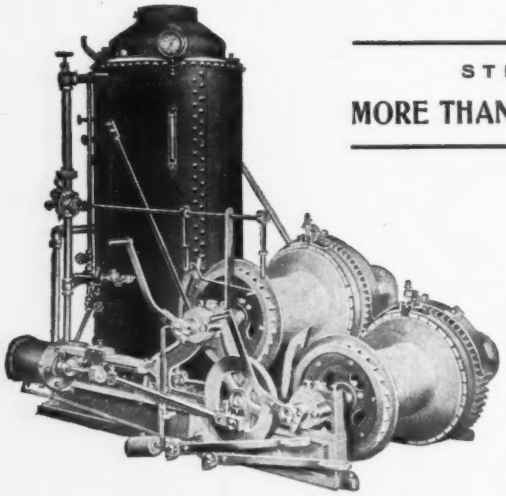

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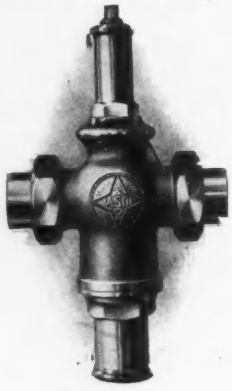

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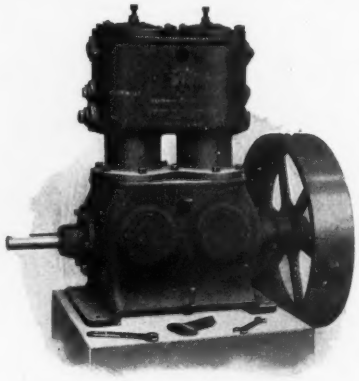

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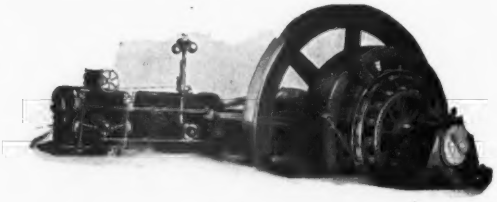

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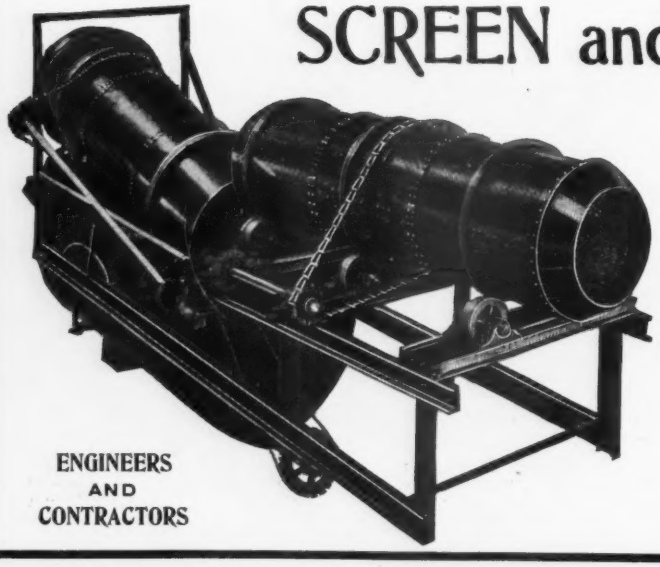

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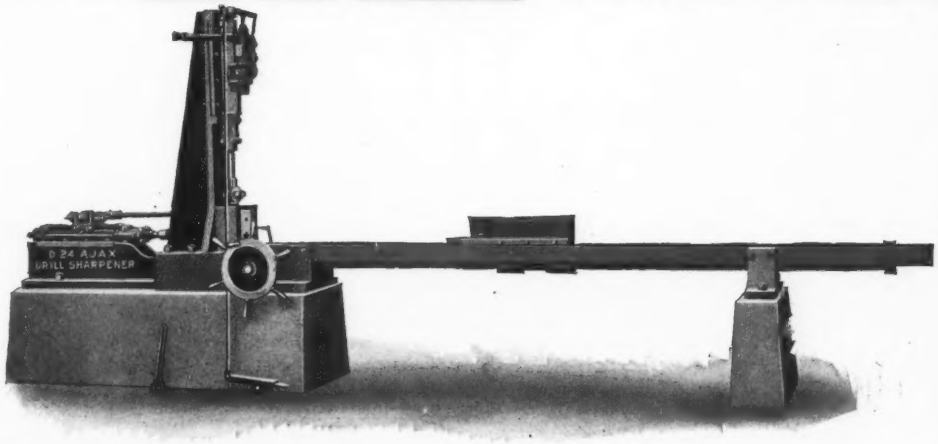

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COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

Vol. XVI JANUARY, 1911 No. 1

GEORGE WESTINGHOUSE TELLS OF THE INVENTION AND DEVELOPMENT OF THE AIR BRAKE

Perhaps the most notable event of the annual meeting (Dec., 1910) of the American Society of Mechanical Engineers, was the address by the President of the Society, Mr. George Westinghouse, giving his account of the invention of the air brake. We present here an abstract of the essential portions of this address.

Mr. Westinghouse was first led to apply his mind to the devising of means for the braking and control of trains in 1866, by a collision on the road between Schenectady and Troy which resulted in his detention for a couple of hours. He first tried familiar and obvious devices which already in some form had been tried by others and he concluded that he would have to seek success in other directions.

He goes on to say: Shortly after I had reached this conclusion, I was induced by a couple of young women who came into my father's works to subscribe for a monthly paper, and in a very early number, probably the first one I received, there was an account of the tunneling of Mount Cenis by machinery driven by compressed air conveyed through 3,000 feet of pipes. This account of the use of compressed air instantly indicated that brake apparatus of the kind contemplated for operation by steam could be operated by means of compressed air upon any length of train, and I thereupon began actively to develop drawings of apparatus suitable for the purpose and in 1867 promptly filed a caveat to protect the invention.

At that time no compressed air of importance had within my knowledge been put in operation. The apparatus was laboriously constructed in a machine shop in Pittsburgh, and completed in the Summer or early Autumn of 1868. This apparatus consisted of an air pump, a main reservoir into which air was to be compressed for the locomotive equipment, and four or five cylinders to be put under the cars, with the necessary piping, all so arranged that their operation as upon a train could be observed. Railway officials were then invited to inspect the apparatus and witness its operation, and the Superintendent of the Panhandle Railroad, Mr. W. W. Card, offered to put the Steubenville accommodation train, a locomotive and four cars, at my disposal. Upon its first run after the apparatus was attached to the train, the engineer, Daniel Tate, on emerging from the tunnel near the Union Station in Pittsburgh, saw a horse and wagon standing upon the track. The instantaneous application of the air brakes prevented what might have been a serious accident, and the value of this invention was thus quickly proven and the air brake started upon a most useful and successful career.

In the development and introduction of the air brake, I was controlled by the apparent fact that the apparatus would have to be uniform upon all cars to provide for the convenient change of the composition of trains. It also was most obvious, in view of the crying demand for some better means for stopping trains, that some power brake would inevitably be universally applied to all of the cars and engines upon all railways. These ideas naturally involved a further one, namely, the importance of having all of the brake apparatus made by one company, so as to insure absolute uniformity and consequent interchange-

ability, and this led to the formation of the Westinghouse Air Brake Company early in 1869.

The essential parts of the air brake as first applied were:

An air-pump driven by a steam engine receiving its supply from the boiler of the locomotive;

A main reservoir on the locomotive into which air was compressed to about 60 or 70 lbs. pressure per square inch;

A pipe leading from the reservoir to a valve mechanism convenient to the engineer;

Brake cylinders for the tender and each car;

A line of pipe leading from the brake valve under the tender and all of the cars, with a pipe connection to each brake cylinder;

Flexible hose connections between the cars provided with couplings having valves which were automatically opened when the two parts of the couplings were joined and automatically closed when the couplings were separated.

The piston of each cylinder was attached to the ordinary hand-brake lever in such a manner that when the piston was thrust outward by the admission of compressed air, the brakes were applied. When the engineer had occasion to stop his train, he admitted the air from the reservoir on the locomotive into the brake cylinders through the train pipe. The pistons of all cylinders were, it was then supposed, simultaneously moved to set all of the brakes with a force depending upon the amount of air admitted.

To release the brakes, the handle of the brake valve was moved so as to cut off communication with the reservoir and then to open a passage from the brake pipe to the atmosphere, permitting the air which had been admitted to the pipes and cylinders to escape.

The success of the apparatus upon the first train was followed by an application of an equipment to a train of six cars on the Pennsylvania Railroad. The train was run to Altoona and the air brakes were used exclusively for controlling the speed of the train on the eastern slope of the Alleghenies, and special stops were made at the steepest portions of the line in such an incredibly short distance (as we all thought then) as to firmly establish in the minds of all present the fact that trains could be efficiently and successfully controlled by means of brakes operated by compressed air.

Mr. Westinghouse then enumerates a number of demonstrations of the brake upon different roads, followed at once by a great rush of orders for equipment.

I refer to these details, he says, to illustrate the readiness with which railway officials took up this invention and the comparative ease with which the required orders were secured, and because it has been often stated that the trials and tribulations in the introduction of the brake were of the severest nature.

It soon developed that it took considerable time to apply the brakes with full force and a longer time to release them, and that in the event of a break-in-two of a train (a frequent occurrence in those days) the rear section would be uncontrolled, and when this occurred upon an ascending gradient, the rear detached section might run away with disastrous results. To overcome this difficulty a new development was necessary, the outcome of which was what has since been known as the automatic air brake.

In the automatic air brake equipment there were the same air-pump, reservoir, train pipe and brake cylinder, but in addition to these there were two important features added to the tender and each car equipment; the first, an auxiliary reservoir, and the second, a triple valve or device interposed between the brake pipe, brake cylinder and auxiliary reservoir. This triple valve was so constructed that when air was admitted to the train pipe, an opening was established between the train pipe and the auxiliary reservoir whereby the train pipe and reservoir were filled with air under pressure. The valve also opened a passage from the brake cylinder to the atmosphere. This was the normal condition of the apparatus when the brakes were off. To apply the brakes, the engineer discharged a portion of the air from the train pipe, whereupon the triple valve closed the connection between the brake pipe and the reservoir and between the brake cylinder and the atmosphere and then opened a passage from the auxiliary reservoir to the brake cylinder, the piston of which was moved outwardly by the air from the auxiliary reservoir so as to apply the brakes. The restoration of the pressure within the brake pipe released the brakes and recharged the reservoir. The development occurred during 1872 and 1873.

The automatic brake was at that time sup-

posed to be instantaneous in its action in applying the brakes, and almost instantaneous in releasing them. In the event of the escape of air from the train pipe by its rupture or by the separation of the train, the air stored in the auxiliary reservoirs instantly and automatically applied the brakes to all parts of the train and they could only be released by either repairing the damage and restoring the pressure, or by means of special release valves operated by the train men.

The automatic brake having proved itself vastly superior to the plain or straight air brake first described, it soon became a standard, but during the transition period an automatic brake was easily converted into a plain brake by a manually operated special valve arranged in the casing of the triple valve.

As a part of the automatic air brake passenger equipment, I had developed in the '70s a system of train signalling involving the use of a second train pipe, which is now in general use upon all of the railways. This signalling apparatus had a sensitive valve device connected to a small reservoir upon the locomotive and these were so arranged that when compressed air was admitted through a small opening into the signalling pipe, both the pipe and reservoir were charged to a low pressure (at the present time at 45 lbs.). By opening a valve at any point in the train to permit a small quantity of air to escape from the signal pipe, the delicate valve referred to was caused to move so as to admit air from its auxiliary reservoir to blow a whistle located in the cab of the locomotive. It was found upon experimentation that when the valve in any car remote from the engine was quickly opened and closed as many as five times, the whistle would be blown an equal number of times, the first time being after the last escape of air; that is to say, there were set in motion five distinct waves of air each capable of doing work.

During these developments it was found that the waves of air within the brake pipe travelled as rapidly as sound, *i. e.*, about 1100 feet a second.

Being fully impressed with the idea that if the wave of air which was utilized for signalling could be made to operate the triple valves upon the cars, there would then be an almost instantaneous application of the brakes upon the front, rear and other portions of the train, this idea, with hard work and a large number of experiments, shortly produced what is now known as the quick-action automatic brake.

No sooner had the quick action automatic brake been developed to operate successfully on trains of fifty cars than new conditions were presented. Steel freight cars carrying enormous loads had in the meantime been developed and freight locomotives had been increased in capacity, so that trains were often composed of seventy to eighty cars, and more recently some trains have had as high as one hundred cars. This possibility had, however, been foreseen and experiments were constantly being carried on to so improve the apparatus, that it could be used to control trains of any practical length, and these experiments also had in view the more nearly instantaneous action of the brakes for ordinary service purposes than was possible with the automatic brake or with the quick action brake. The result was a most important development.

The present improved triple valve has the emergency feature, but it also has what is known as the quick-service application feature, that is, for ordinary purposes the air is admitted to all of the brake cylinders so quickly that the longest freight train can be handled with almost the precision obtainable in the control of passenger trains of from six to twelve cars.

In the matter of the development of the brakes for operation upon passenger trains, nothing that skill and perseverance could suggest has been omitted in securing the highest degree of perfection. The requirements during the past few years, by reason of the greater weight of cars and locomotives and of the higher speeds at which they are run, have necessitated the redesigning of all of the passenger train brake apparatus, including the method of attaching the brake shoes to the cars and the levers and connections for bringing these shoes to bear with the required pressure upon the wheels. For the purpose of insuring the highest efficiency, every wheel of a passenger train, including those under the locomotive, is now acted upon, whereas formerly many of the master mechanics and engineers were apprehensive that it would not be possible to make use of all of the wheels of a locomotive for braking purposes.

During the past twelve months, most elaborate tests of the latest form of apparatus for passenger service have been carried out under the direction of officials of several railways and of the Westinghouse Air Brake Company, in order to prove the operativeness of the new constructions and their capability to insure the highest degree of efficiency.

I have spoken of four chief developments. It has been necessary, in order to avoid disastrous consequences, that each development should be of such a kind that cars fitted with newer apparatus could operate with little inconvenience with cars fitted with earlier apparatus. As it stands to-day, scarcely any of the old type of brake and the first type of automatic brake are in use, but should a car fitted with the first form of automatic brake be found and put into a train with the more modern apparatus, such older apparatus would be found to operate fairly well with the more perfect form. The prevailing idea in the development and introduction of the brake has therefore been an adherence to such uniformity of apparatus that the interchange of traffic over various roads could go on uninterruptedly.

There is probably no apparatus in use today which received such thoughtful consideration and has been the object of such care in every one of its details as what is now popularly known as the air brake, and which is in universal use in the United States and in many other countries of the world.

In my estimation, there could be no better illustration of the value of the maintenance of standards than has been given by the manufacture and introduction of air brakes upon railways, for without such standards, train brakes would not have come into general use, with consequences which railway officials and the public can well appreciate.

My story would be incomplete without a reference to the splendid assistance which the railways of this and many other countries have rendered. They have been lavish in providing those facilities for making the thousands of tests which were necessary to progress in the developments I have recited; to the Pennsylvania Railroad especially, upon which the most important experiments were first made, the other railways of the country, as well as the traveling public, owe a debt of gratitude. When a railway (as did the Southern Pacific two years ago) provides a new train of one hundred steel cars to be fitted with the newer form of automatic brake, in order to carry on, with a staff of skilled men under the direction of the chief officers of the company, a series of experiments upon its heaviest gradients, requiring several weeks, for the purpose of securing greater safety and an increased carrying capacity per train, with the consequent lessening of the cost of transportation, it is just that the managers of such a corporation should receive credit for their farsighted policy. To name the railways and to merely state chronologically the tests of brakes which have been made during forty years would require several volumes.

TRANSPORTING LIVING ANIMALS IN WATER JARS CHARGED WITH OXYGEN

By Dr. Raymond C. Osborn, Assistant Director of the New York Aquarium.

A very interesting experiment in the transportation of aquarium specimens has recently been made by Mr. Emil Gundelach, of Gehlberg, Germany, with the assistance of the New York Aquarium. Arrangements were made through the forwarding house of Oelrichs & Co., of New York, for the shipment of living specimens from the Aquarium to Mr. Gundelach's home in Germany.

Sixteen 3-liter glass jars were filled with water and the specimens introduced. The jars were then inverted under water, as in a pneumatic trough, and oxygen gas was introduced to replace the water until the jars were about one-third full of the oxygen. The jars were then tightly corked and covered with parchment to prevent an escape of the gas. They were packed in crates and shipped at once on the North German Lloyd steamer, *Kaiser Wilhelm der Grosse,* on the morning of September 13.

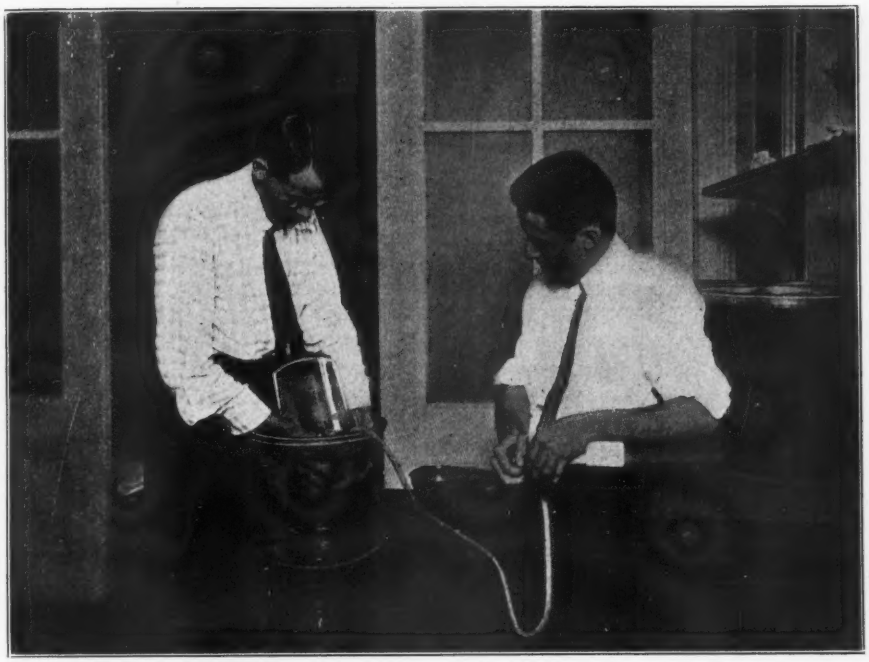
The list of specimens for this experiment was as follows:

Common sunfish (*Eupomotis gibbosus*) in fresh water.

Variegated minnow (*Cyprinodon variegatus*).

Cunner (*Tautogolabrus adspersus*).

Beau Gregory (*Eupomacentrus leucostictus*).



CHARGING WITH OXYGEN AND CLOSING THE JARS.

Star corals (*Astrangia danae*).
Sea anemones (species undetermined).
Tunicates (*Molgula manhattensis*).
Common shrimps (*Crangon vulgaris*).
Horseshoe crabs (*Limulus polyphemus*), a couple of dozen of young, just hatched, and one so large that it could not straighten out in the jar.

Fiddler crabs (*Uca pugnax*), several specimens in wet sand, with an atmosphere of oxygen.

An extract from Mr. Gundelach's letter of September 26, acknowledging the receipt of the specimens, shows what success was met with: "The collection arrived at Gehlberg on the evening of September 22. Notwithstanding the length of time (over nine days) the specimens reached my home in safety. The Beau Gregory and the Cunner got chilled because the temperature was too low, and both of these fishes died the next day, but all the other specimens lived and are in the best of condition. It is very important that the experiment has succeeded, and you can now exchange any specimens with any European institutions in this way."

In order to know what losses, if any, might be laid to temperature Mr. Albers, second officer of the ship, kindly consented to make daily records of the temperature of the room in which the crates were placed through the voyage. His report indicates a gradual decrease from 73 degrees to 66 degrees Fahrenheit, and Mr. Gundelach informs me in his letter that it was as low as 63 degrees in Germany at the time the specimens arrived there. The Beau Gregory, being a tropical fish, evidently did succumb to the cold, but the Cunner is a northern form and the same explanation will not apply. The specimen was probably too large for the jar and the supply of oxygen. It was the largest fish sent and was selected to test the size limit. It did not, however, suffocate during shipment, but it was probably weakened by confinement for so long a time in its very narrow quarters, and possibly the oxygen supply ran a little short. The journey was made entirely without food.

Mr. Gundelach had previously made successful experiments in shipping for the shorter distances in Europe, but nothing paralleling the present experiment has thus far been un-

dertaken. The particular advantage in this method is that specimens can be sent apparently any distance without any care whatever during transit, thus doing away entirely with the expense of an attendant or any special machinery for aerating the water—*North German Lloyd Bulletin.*

AIR OF THE NEW YORK SUBWAY

BY DR. GEO. A. SOPER.

When the New York subway was first opened there was a good deal of complaint as to the condition of the air. The subway grew hot and there were unpleasant odors. Some more or less scientific people made a few quick-and-easy determinations of the oxygen and the carbon dioxide in the air, and published alarming reports in the newspapers. Professor Chandler, of Columbia University, made some careful examinations of the carbon dioxide, which were reassuring enough for him and for many others, but the Rapid Transit Railroad Commissioners were not fully satisfied. They held the view that here was a great experiment. The subway was certainly uncomfortable. Something was the matter with the ventilation. Was the air dangerous to breathe? If the air was bad and could not be made wholesome, there would be no more subways built. The importance of this question was considered great enough to warrant thorough investigation. I was asked to make the investigation and did so.

The temperature and humidity were determined. There were 50,000 determinations of the temperature and humidity. The oxygen was estimated; there were 80 determinations of oxygen. The carbon dioxide was determined; there were 3,000 analyses of that. The numbers of bacteria were determined; there were about 2,500 bacteriological examinations. The dust was analyzed. I found the problem to be largely one of dust, so far as health was directly and seriously concerned.

I found at the outset that the ordinary quick-and-easy methods of analysis employed in most ventilation work were not suitable for this case. And so the most accurate determinations which it was practicable to make on a large scale and under the difficult conditions of subway traffic were employed.

It was only by the most refined methods that we could detect any difference between the oxygen in the subway and that in the outside air. The difference averaged only about 1½ parts of carbon dioxide per 10,000 parts of air. It was almost incredible that such a slight difference should exist while the air in the subway was so unpleasant, yet the fact could not be disputed.

It was difficult to get samples. It was desirable that they should be collected, as far as possible, away from people. So I had the sample bottles put in a basket with a pump and a thermometer. The investigator appeared to be a young man proceeding to market. He would go to the part of the subway previously determined on, await his opportunity and then take the cover off the basket sufficiently to insert a rubber tube. Then with the air pump he would pump air through a flask until the flask was filled with the air to be analyzed. I found we could get a reliable sample in that way, and in that way alone.

Fig. 1 shows some of the results. There were about 2,000 analyses averaged to get the figures from which these curves were made. The amount of carbon dioxide in the air of the subway is shown by the heavier upper line; that in the streets by the lighter line below. Note the correspondence between the rising and the falling of these two lines.

You see the observations extended over several months. I found there was a difference in the amount of carbon dioxide in the air of the streets at different hours of the day. Rush hours in the subway always gave larger amounts of carbon dioxide than other hours. And, curiously enough, the rush hours in the subway appeared to be the rush hours in the streets. Apparently, the air in the streets was affected by the great numbers of people in them. The striking rise shown in December is due to the large increase in the number of people using the subway and streets. It was the Christmas season.

There were regular variations in the chemical condition of the air at different hours of the day and night. At six o'clock in the morning the carbon dioxide in the subway was at a minimum. It then increased rapidly up to the end of the morning rush hour. From the end of the morning rush hours, there was a gradual reduction until just before noon, when the reduction ceased and there was a slight increase. The increase

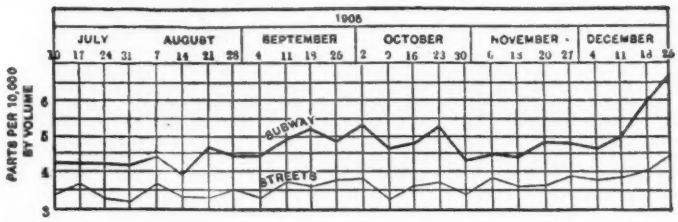


FIG. 1.

was apparently due to the fact that there was a slight rush of people who used the subway about noon in the shopping district. After noon there was a progressive reduction down to the beginning of the rush hours of the afternoon, when there was a decided increase. From that time there was a pretty constant reduction until morning.

There was much more carbon dioxide at six o'clock at night than during the rush hours of the morning, because more people traveled at that time. The crowding was much greater because the rush period was shorter. Most of the people who went to business between seven and nine wanted to get home as soon after six as possible.

Fig. 2 shows a compound diagram which may need a word of explanation. We have here the amount of carbon dioxide found at the different stations. The subway, you know, is 20 miles long, and the most interesting part of it, from the standpoint of ventilation, is between Brooklyn Bridge and Seventy-ninth Street. This diagram represents the conditions between those two points. The amount of carbon dioxide in the air at different stations for the period from July 14 to September 1 lies along the lower broken line. Now, later in the season, when more people were traveling, there was much more carbon dioxide at those stations. We have this fact shown on another broken line. Later, in November, when the heat began to abate and more active business conditions led more people to take the subway, there was a further increase in the amount of carbon dioxide, and so on until the end of December. There is one diagram for the afternoon hours and one for the morning hours. For each station you will find on this diagram the amount of carbon dioxide for the months covered in the investigation.

One of the most useful results of the whole work is illustrated in Fig. 3. The point illustrated is that a distinct relation existed between the number of openings to the street and the condition of the air. I think you can follow the diagram without my aid. It led me to the opinion, which I have since been able thoroughly to confirm, that the New York subway and other subways of its kind will ventilate themselves if they are given a chance. The New York subway did not have

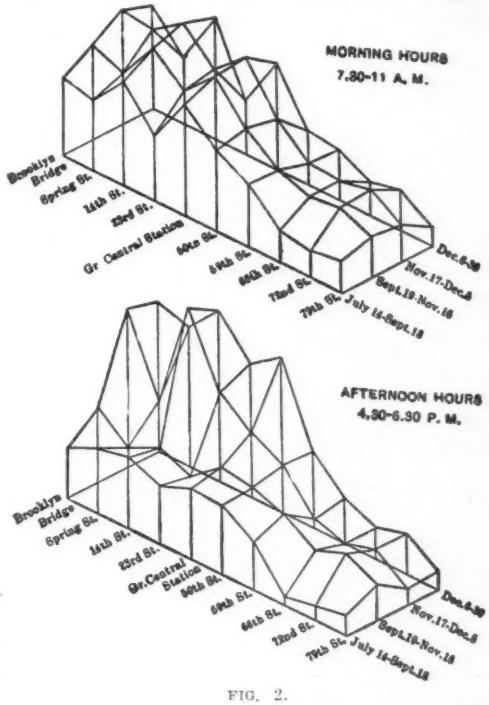


FIG. 2.

a chance, and the Paris subway did not, for the reason that it was too tightly enclosed for the air to move in and out with the requisite freedom.

It is not necessary to put fans into subways like the New York subway. In fact, it is doubtful if fans, even on the largest scale practicable, will produce material improvement, except immediately at the points where,

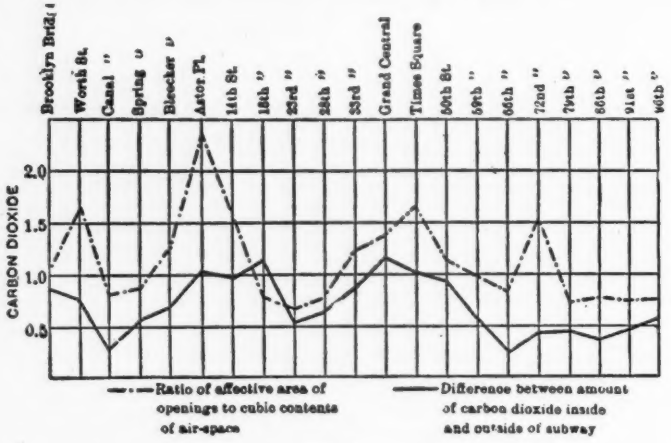


FIG. 3.

for example, outside air is pumped in. Fans will not improve the air sensibly for any considerable distance. This was proved by my investigations. But if you will give the subway openings enough, it will breathe of itself. The breathing bears a rather close analogy to the breathing of animals.

The subway in New York has been materially improved by providing blow-holes through which the air set in motion by the trains can move in and out. I have said the need of so much opening was not evident at first.

As was said, the fans did not materially improve the general air in the subway; the blow-holes did. Before the fans were put in it is probable that the air was renewed once every half hour. The amount of renewal after large sections of the roof were opened was very great. It wasn't possible to tell exactly how often the air was renewed, for the reason that the number of people traveling in the subway was not known by the city. There was no census of travel for a long time

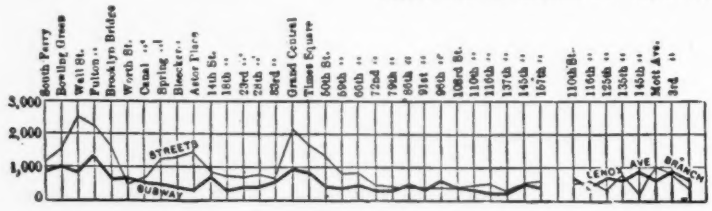


FIG. 4.

Bacteriological examinations of the air were made. Professor Sedgwick devised filters for air some years ago, and it was partly upon his plan that our filters were devised. They are small tubes filled with sand and plugged with cotton at both ends. We fastened two filters in tandem on a rubber tube, which was connected with a well made and carefully operated pump. The number of strokes of the pump gave us the quantity of air passed through the filters. In passing through the filters the air parted with its germs. After filtration the filters were taken to the laboratory and there dealt with in a after the subway was put in operation, and none until after my investigations had been completed.

In Fig. 4 you see the results of determinations of the number of bacteria at the different stations throughout the length of the subway and in the streets overhead. There is a general correspondence between these two sets of figures. The average of all the analyses shows that about half as many bacteria were found in the air of the subway as in the air of the streets. The numbers of bacteria varied with a good many circumstances, one of them being the amount of air moving in the subway.

TABLE. — EFFECT ON THE NUMBERS OF BACTERIA IN THE AIR OF THE SUBWAY PRODUCED BY SWEEPING THE PLATFORMS IMPROPERLY.

PLACE.	TIME, A.M.	MICROÖRGANISMS PER CUBIC METER OF AIR.		RATIO OF BACTERIA TO MOLDS.
		Bacteria.	Molds.	
Fulton Street Station, South End, west platform. Remote from openings to streets	10.25	4 900	100	49 : 1
Porter began sweeping near by	10.41	13 200	50	264 : 1
Still sweeping, but farther off	10.57	8 100	0	.....
Still sweeping, middle of platform	11.12	8 500	0	.....
Average	.....	8 600	38	226 : 1

The accompanying table tells its own story and shows the effect of improper methods of cleaning. The porters swept the platforms without first moistening them, and this greatly increased the numbers of bacteria in the air. The movement of the trains kept the bacteria in the air because the movement of trains set the air in motion, and the dust particles, which we will consider later, were kept afloat also by the air currents.

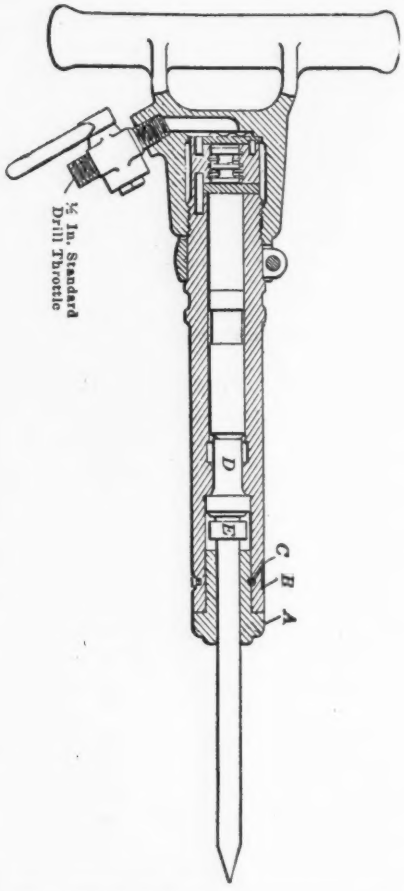
It was very difficult to devise a plan for determining the quantity of dust in the air. The difficulty lay in the necessity of examining a large volume of air. The amount of dust was small to separate and weigh with accuracy, so that a special apparatus was employed. It consisted partly of an ordinary Root blower, adjusted so that it drew air through a gas-meter. The meter was carefully tested and found to work with sufficient accuracy in this manner. A filter was attached to the gas meter, so that when this pump was operated, the air passed down through the filter to the meter. The filter was composed of sugar. After a sufficient number of cubic feet of air had been passed through the filter, the filter was disconnected and taken to the laboratory. There the sugar was dissolved in water. The water was then filtered and the solid particles were dried and weighed.

The world's production of metallic aluminum has risen from about 7,300 tons in 1900 to 24,200 tons, last year.

FIRING OF GASES BY COMPRESSION

At a recent meeting of the Manchester, Eng., School of Technology, Professor Dixon gave an address on the above topic. Professor Dixon said that the importance of the ignition point of gases lay, he thought, in two things—one, the theory of the combustion of gases and the explosion of gases, and the other, the fact that the ignition of gas by compression was an actual industrial process in certain gas engines, and might soon be in motors. Dr. Coward and he had been conducting research work for some years on the determination of the ignition point of gases, and while they had been working a paper appeared in an American journal by Mr. Falk, who, working with Professor Nernst, at Berlin, had carried out similar research by compressing the gases suddenly by a piston in a cylinder and determining the volume to which it was necessary to compress them before they fired. The results obtained by Nernst's method were in agreement with some of the results he and Dr. Coward has obtained, but were very different from some other experiments of theirs. Professor Dixon said that he had been investigating the causes of these differences, and he had found that the chief cause was that some gases heated themselves far more rapidly than others before the flame appeared, and this pre-flame period was a very important period in the ignition of gases—that was to say, it might take a considerable time during which the gases were heating themselves up. He went

on to show and to explain an apparatus by which it was possible to determine the real ignition point by the compression of gases independently of this pre-flame period.



CUTTING TIMBERS WITH AIR HAMMERS

By S. H. Hill.

In the Lake Superior district it has been customary to cut the hitches required in timbering by hand, usually with a moil. However, since a great number of first-class air-hammer drills have come upon the market the use of an air moil for this work has met with favor upon the grounds of economy and speed. The air moil can, of course, only be used in headings that are piped for air. A reducer can be used on the end of the pipe and air for the hand tool taken from the nipple used for heading machines. However, this necessitates doing the hitch cutting or squaring when the heading machines are not in use or while one of them has been purposely stopped. The introduction of a manifold on the end of air pipe, having one opening especially for the hand tool is more satisfactory.

A standard tool, such as shown in the accompanying illustration, of the Hornet hand hammer drill manufactured by the Ingersoll-Rand Company, is used for this work. The hand drills now on the market vary in weight from 20 lb. up. The bushing *A* for the drill steel is removable from the cylinder upon the removal of dowel pin *C*, which is held in place by snap spring *B*. As is seen, quite a recess is afforded between the rear end of the bushing *A* and the front end of anvil block *D*. In practice, steel of proper form to fit whatever bushing the drill is equipped with, is used. One end of this steel is shaped into a moil bit (which at no place can exceed the diameter of the steel itself) and the other end upset in such a way that it will ride easily in the recess between the bushing and anvil block, and at the same time the steel will be prevented from being shot from the drill in case the moil is not tight against the ground. The moil can be removed from the hammer drill by removing snap spring *B*, dowel pin *C* and pulling out both the moil and bushing. The bushing can then be taken from the moil by simply slipping it over the point. The use of the above-described contrivance means a saving of time. There is also a possibility of making use of this outfit in sampling breasts, etc.—*Engineering and Mining Journal.*

VARIETIES OF POWER APPLICATIONS IN A RAILROAD SHOP

An installation of considerable interest for the varied use to which the power is put, is the plant of the railroad repair shops of the New York Central Lines at West Albany, N. Y. Electric current, both alternating and direct, is used for lighting and power to a considerable extent. For transmission from the power house to the various parts of the shops the current, which is generated at 480 volts, 3-phase 60 cycle, is stepped up to 2,300 volts, and at each shop stepped down through transformers for operating the induction motors. Arc lights in the yards are on the alternating-current circuit, while to provide direct current for incandescent lighting and about 40

per cent. of the motor load there is a direct-current service of 250 volts generated by 3 motor generator sets. Compressed air to the extent of 95,000,000 cu. ft. per month is furnished at an average pressure of 90 lb. per sq. in. by two Ingersoll-Rand 360-hp. compressors, this service being used for operating pneumatic tools, boiler tube cleaners, and for testing air brake equipments, and various other uses. Hydraulic power also is used to a large extent, principally for pipe testing and similar uses, and to supply the necessary amount of water under pressure, a three million gallon service pump is provided.

OLD BOILER TUBES

An exchange advises its readers that "old boiler tubes which are merely rusted out at the ends may generally be utilized by re-threading and used as air or water pipes. Often they are thrown away as useless, but it is rarely the case that they will not withstand a pressure of 100 lbs., or even more."

On the word of an old machinist of the shop, the scheme will not work. Boiler tubes are so thin that a threading tool would almost cut through them, and besides that their external diameters do not correspond with those of standard pipe fittings. Old tubes are often made "good as new" by cutting off the bad ends and then welding or brazing a piece to one end sufficient to make up the required length.

CLEAN INTAKE AIR FOR TROLLEY CAR COMPRESSORS

The lines of the Rhode Island Company, of Providence, R. I., traverse a country which is largely underlaid with slate, and the mechanical department has experienced much trouble from grit and dust cutting the teeth of motor gears and pinions and compressor gears. Master Mechanic W. D. Wright has largely overcome these troubles by placing felt shields on the motor cases and by piping the compressor air from points above the car roof. On a number of open cars this has been done by utilizing two of the down spouts designed to carry off water from the eave troughs, while on closed cars pipe is carried up back of the controller and up through the roof. By this method clean air for the compressor is secured at all times.

HIGH PRESSURE MANUFACTURED GAS FOR FUEL

The Birmingham, Eng., Gas Committee are anxious to encourage the use of high-pressure gas as fuel instead of coal or coke in manufactories and workshops. As a test, high-pressure gas has been installed on a large scale at the works of the Birmingham Aluminum Casting Company. The furnace has a fireclay surround of 3½ in. in thickness, to which the gas is conducted in high-pressure resisting pipes. There is no necessity for any special burner, but a careful adjustment of the air aperture in the furnace is essential, after which no other attention than lighting is required. When the gas has been lighted, the crucible, which is capable of holding more than I cwt. of aluminum, is raised to a high temperature, and the metal is brought to a fluid state in about sixty-five minutes at a cost of 1s. 4d.

SAMPLING SCREEN DRIVEN BY COMPRESSED AIR

Several interesting labor-saving devices are used in the fine-grinding room of the sampling works of the Cananea Consolidated Copper Company. One of these is an air-actuated sampling screen. It consists of an ordinary screen held in a light steel frame, attached to the piston of a small air hammer.

The usual 80-mesh screen with the sample in it is placed in the frame. The attendant turns on the air and merely holds his hand on the screen, steadying it in its back and forth motion. The stroke is about 1½ in. and the compressed air is taken from a main at about 80 lb. pressure. With this device it is possible to screen from 50 to 60 samples per hour while formerly a Mexican screened only from 20 to 25 per hour.—*Engineering and Mining Journal.*

MEASURING ALTITUDES WITH THE ANEROID BAROMETER

For approximately measuring differences of elevation between two points where the observations can be made with only short intervals of time between them the aneroid barometer is very useful, but if much time elaspes the measurements may not be accurate on account of the changes of the local atmospheric pressure. On a certain occasion an ex-

cellent barometer indicated an altitude of 1,600 ft. It was carried up a hill to the summit of a ridge where it read 1,900 ft. Twenty minutes after the first reading, on returning to the gulch the instrument indicated 1,615 ft., showing a discrepancy of 15 ft. This is the way of the aneroid barometer. The depth of a shaft can usually be determined with considerable accuracy if there be no delay in going from one level to another, or from the top to the bottom. If there be delay from one level to the next, take separate readings, and then take several trips, reading both top and bottom. From these several readings take the mean, which should agree closely with the actual figures as determined by leveling.

HORSE POWER FOR COMPRESSING AIR

[The following article by Mr. J. William Jones, Painted Post, N. Y., we are enabled to reproduce by the kind permission of the editor of *Machinery* in which it first appeared, the tables constituting a portion of the December contribution to the valuable series of Data Sheet Supplements regularly accompanying that publication. The entire matter is copyrighted by the Industrial Press of New York.]

In estimating the various items in compressed air computations, it is customary to employ formulas previously determined, and generally published in various hand-books. This custom not only eliminates the possibility of errors, but saves time that would otherwise be used in long calculations. For the same reason the tables accompanying this will be found valuable to those who have to deal with calculations relative to compressed air.

When air is compressed in a cylinder without the removal of any heat due to compression, the compression is termed "adiabatic." On the other hand, when the heat of compression is removed as fast as produced, the compression is known as "isothermal." Neither of the above conditions are ever met with in actual practice. The actual compression curve, however, follows the adiabatic curve closely, and we, therefore, assume that the compression is adiabatic, as any slight difference is on the safe side. Isothermal compression is an impossible ideal, and the horsepower, mean effective pressure, etc., relating to isothermal compression are employed in the making of comparisons only.

The formula for calculating the horsepower required to compress, adiabatically, a given volume of free air to a given pressure is as follows:

$$\text{H.P.} = \frac{144\ N\ P\ V\ n}{33000\ (n-1)} \left[\left(\frac{P_s}{P} \right)^{\frac{n-1}{Nn}} - 1 \right]$$

In which

N=number of stages in which compression is accomplished,

P=atmospheric pressure in pounds per square inch,

P_s=absolute terminal pressure in pounds per square inch=gage pressure plus atmospheric pressure.

V=volume of air in cubic feet, to be compressed per minute, at atmospheric pressure,

n=exponent of the compression curve, taken as 1.41 for adiabatic compression.

Simplifying the above formula for the different stages and for a value of one cubic foot we have:

For one-stage compression:

$$\text{H.P.} = 0.015\ P\ (R^{0.29} - 1)$$

For two-stage compression:

$$\text{H.P.} = 0.030\ P\ (R^{0.145} - 1)$$

For three-stage compression:

$$\text{H.P.} = 0.045\ P\ (R^{0.097} - 1)$$

For four stage compression:

$$\text{H.P.} = 0.060\ P\ (R^{0.0725} - 1)$$

In these formulas $R = \frac{\ }{P}$ = number of atmospheres to be compressed.

For computing the horsepower required to compress, isothermally, a given volume of free air to a given pressure, the following formula should be employed:

$$\text{H.P.} = \frac{144 \times PV}{33000} \left(\text{Nap. log.} \frac{P_s}{P} \right)$$

The Napierian logarithm is obtained by multiplying the common logarithm by the factor 2.302585.

In the fourth and fifth columns of the tables for two- and three-stage compression, it will be noticed that these columns cover the cor-

Horsepower Required for Compressing One Cubic Foot of Free Air per Minute (isothermally and Adiabatically) from Atmospheric Pressure (14.7 pounds) to Various Gage Pressures.

Single-Stage Compression.

Initial Temperature of Air taken as 60°F.—Jacket-cooling not considered

Gage Pressure, Pounds	Absolute Pressure, Pounds	Number of Atmospheres	Isothermal compression: Mean Effective Pressure	Isothermal compression: Horsepower	Adiabatic compression: Mean Effective Pressure, Theoretical	Adiabatic compression: Mean Eff. Pressure plus 15 per cent Friction	Adiabatic compression: Horsepower, Theoretical	Adiabatic compression: Horsepower plus 15 per cent Friction
5	19.7	1.34	4.13	0.018	4.46	5.12	0.019	0.022
10	24.7	1.68	7.57	0.033	8.21	9.44	0.036	0.041
15	29.7	2.02	11.02	0.048	11.46	13.17	0.050	0.057
20	34.7	2.36	12.62	0.055	14.30	16.44	0.062	0.071
25	39.7	2.70	14.68	0.064	16.94	19.47	0.074	0.085
30	44.7	3.04	16.30	0.071	19.32	22.21	0.084	0.096
35	49.7	3.38	17.90	0.078	21.50	24.72	0.094	0.108
40	54.7	3.72	19.28	0.084	23.53	27.05	0.103	0.118
45	59.7	4.06	20.65	0.090	25.40	29.21	0.111	0.127
50	64.7	4.40	21.80	0.095	27.23	31.31	0.119	0.136
55	69.7	4.74	22.95	0.100	28.90	33.23	0.126	0.145
60	74.7	5.08	23.90	0.104	30.53	35.10	0.133	0.153
65	79.7	5.42	24.80	0.108	32.10	36.91	0.140	0.161
70	84.7	5.76	25.70	0.112	33.57	38.59	0.146	0.168
75	89.7	6.10	26.62	0.116	35.00	40.25	0.153	0.175
80	94.7	6.44	27.52	0.120	36.36	41.80	0.159	0.182
85	99.7	6.78	28.21	0.123	37.63	43.27	0.164	0.189
90	104.7	7.12	28.93	0.126	38.89	44.71	0.169	0.195
95	109.7	7.46	29.60	0.129	40.11	46.12	0.175	0.201
100	114.7	7.80	30.30	0.132	41.28	47.46	0.180	0.207
110	124.7	8.48	31.42	0.137	43.56	50.09	0.190	0.218
120	134.7	9.16	32.60	0.142	45.69	52.53	0.199	0.229
130	144.7	9.84	33.75	0.147	47.72	54.87	0.208	0.239
140	154.7	10.52	34.67	0.151	49.64	57.08	0.216	0.249
150	164.7	11.20	35.59	0.155	51.47	59.18	0.224	0.258
160	174.7	11.88	36.30	0.158	53.70	61.80	0.234	0.269
170	184.7	12.56	37.20	0.162	55.60	64.00	0.242	0.278
180	194.7	13.24	38.10	0.166	57.20	65.80	0.249	0.286
190	204.7	13.92	38.80	0.169	58.80	67.70	0.256	0.294
200	214.7	14.60	39.50	0.172	60.40	69.50	0.263	0.303

TABLE I.

rect ratio of the cylinders, and the intercooler pressure, respectively. The correct ratio of cylinders (r) is obtained by the following formula:

For two-stage compression:

$$r = \sqrt{\frac{P_3}{P}}$$

For three-stage compression:

$$r = \sqrt[3]{\frac{P_3}{P}}$$

Thus, for two-stage compression we extract the square root of the number of atmospheres to be compressed, and for three-stage we extract the cube root. This proportion of cylinder volumes divides the work equally between the different stages, providing the intercooler abstracts all the heat due to compression in the preceding stage. The intercooler gage pressures, as shown in the fifth column, are obtained by multiplying the absolute intake pressure by the ratio of the cylinder volumes, and subtracting from this result the atmospheric pressure. It should be remembered that the intake pressure of the second-stage cylinder of any three-stage machine is the absolute intercooler pressure from the cooler between the first and second stages.

Let

P_1=intercooler pressure between first and second stages,

P_2=intercooler pressure between second and third stages,

Then, for two-stage compression:

$$P_1 = \left(P \times \sqrt{\frac{P_3}{P}} \right) - P$$

For three-stage compression:

$$P_1 = \left(P \times \sqrt[3]{\frac{P_3}{P}} \right) - P$$

$$P_2 = \left(P_1 \times \sqrt[3]{\frac{P_3}{P}} \right) - P$$

It is sometimes advantageous to know the mean effective pressure per stroke as shown in the tables. By dividing 144 by 33,000 we obtain a factor 0.00436, which divided into the horsepower will give the mean effective pressure per stroke.

CANAL ZONE MEETING, AMERICAN INSTITUTE OF MINING ENGINEERS

The Canal Zone Meeting of the American Institute of Mining Engineers began on October 21 and ended on November 15. The steamer Prinz August Wilhelm of the Hamburg-American Line was chartered and the party consisted of 121 persons, most of them members of the Institute, there being 84 men, the balance being made up of wives, daughters and guests.

It is doubtful whether the Institute has ever before gathered so representative a body of its members in any one excursion. An analysis of the list shows that 36 colleges were represented and that of the 84 men 60 were college men. Columbia and Lehigh led with 10 representatives each, Harvard and the University of Pennsylvania following, the balance being distributed over nearly every college in the country. Eighteen states were represented.

Metal mining was represented by such men as Hennen Jennings, Gardner F. Williams, H. C. Perkins, all veterans of early South African mine developments, Mr. Williams having been for some eighteen years the General Manager of the De Beers & Kimberley diamond mines, Messrs. Perkins and Jennings representing the Robinson and other Werner-Beit properties, the largest and richest gold mines in Africa. All three of these men have international reputations, made because of their skill and character. The work they did in South Africa, and the reputations they made did credit to their American citizenship, and no one envies them the fortunes which they have made and the pleasures which they now enjoy. Other miners in precious metals were R. B. Watson, General Manager of the Nipissing and La Rose mines at Cobalt, Ontario; W. E. C. Eustis, of Boston; A. C. Carson, of New York; Walter J. Page, Manager of the Guggenheim Smelters at Omaha; and Harry C. James and David G. Miller, of Denver.

Copper and other metal mining interests were represented by George D. Barron, C. W. Goodale, Manager of the Boston & Montana, Butte; William Kelly, General Manager Penn. Iron Mining and Republic Mines in Michigan; and David W. Brunton, of Denver.

More than fifty per cent. of the anthracite coal producers were represented in person, among them being W. J. Richards, Vice-President of the Reading Coal & Iron Company, with a pay-roll of twenty millions a year, (larger than that of the Panama Canal) and with an equal number of men employed; that is, 33,000. W. A. Lathrop, President of the Lehigh Coal & Navigation Company; S. D. Warriner, Vice-President and General Manager of the Lehigh Valley Coal Company; R. V. Norris, of Wilkes-Barre; James S. Cunningham, of Johnstown, Pa.; H. N. Eavenson, Chief Engineer of the United States Coal & Coke Company, of West Va.; Rowland F. Hill, of Pulaski, Va.; Eugene McAuliffe, Chicago; Samuel A. Taylor, Pittsburg; Philip Goodwill, formerly President of the Pocahontas Company, of West Virginia; W. S. Ayres, of Hazleton, Pa.; and F. W. Scarborough, of Richmond, Va.

In other branches of engineering were Dr. Drinker, President of Lehigh University; Prof. Richards, of Lehigh; William Kent, Dr. Raymond, Charles Kirchhoff, Col. D. C. Dodge, the railroad builder of Denver; Edward W. Parker, D. M. Riordan, David B. Rushmore, Dr. Struthers, Jos. Underwood, Thos. Robbins, Howard Wood and Walter Wood, of Philadelphia; C. M. Russell, of Massillon, Ohio; and Frank M. Warren, of Minneapolis.

Perfect weather was enjoyed from New York to Havanna, notwithstanding the apprehensions felt because of the recent hurricanes. There was an informal reception held on shipboard on Saturday, the day following that of sailing, which brought the members and their guests together. Much interest was excited by an exhibition made by Mr. Gardner Williams of diamonds taken from the Kimberley mines.

On Saturday, October 23, religious service was held in the dining saloon, conducted by Dr. Raymond.

For the first time it was noticed that the eminent Doctor is a singer as well as a preacher, and on this occasion he sang with such zeal that his voice commanded a halt when his sermon had run but twenty minutes. The Doctor spoke of immortality, and at the end of the service the Captain of the ship added a peroration to the sermon by calling attention to the fact that the sea beneath us was two

Horsepower Required for Compressing One Cubic Foot of Free Air per Minute (Isothermally and Adiabatically) from Atmospheric Pressure (14.7 pounds) to Various Gage Pressures.

Two-Stage Compression.

Initial Temperature of Air-taken as 60°F.-Jacket-Cooling not considered

Gage Pressure, Pounds	Absolute Pressure, Pounds	Number of Atmospheres	Correct Ratio of Cylinder Volumes	Intercooler Gage Pressure	Isothermal Compression: Mean Effective Pressure	Isothermal Compression: Horsepower	Adiabatic Compression: Mean Eff. Pressure, Theoretical	Adiabatic Compression: Mean Eff. Pressure plus 15 per cent Friction	Adiabatic Compression: Horsepower, Theoretical	Adiabatic Compression: Horsepower plus 15 per cent Friction	Percentage of Saving over One-Stage Compression
50	64.7	4.40	2.10	16.2	21.80	0.095	24.30	27.90	0.106	0.123	10.9
60	74.7	5.08	2.25	18.4	23.90	0.104	27.20	31.30	0.118	0.136	11.3
70	84.7	5.76	2.40	20.6	25.70	0.112	29.31	33.71	0.128	0.147	12.3
80	94.7	6.44	2.54	22.7	27.52	0.120	31.44	36.15	0.137	0.158	13.8
90	104.7	7.12	2.67	24.5	28.93	0.126	33.37	38.36	0.145	0.167	14.2
100	114.7	7.80	2.79	26.3	30.30	0.132	35.20	40.48	0.153	0.176	15.0
110	124.7	8.48	2.91	28.1	31.42	0.137	36.82	42.34	0.161	0.185	15.2
120	134.7	9.16	3.03	29.8	32.60	0.142	38.44	44.20	0.168	0.193	15.6
130	144.7	9.84	3.14	31.5	33.75	0.147	39.86	45.83	0.174	0.200	16.3
140	154.7	10.52	3.24	32.9	34.67	0.151	41.28	47.47	0.180	0.207	16.7
150	164.7	11.20	3.35	34.5	35.59	0.155	42.60	48.99	0.186	0.214	16.9
160	174.7	11.88	3.45	36.1	36.30	0.158	43.82	50.39	0.191	0.219	18.4
170	184.7	12.56	3.54	37.3	37.20	0.162	44.93	51.66	0.196	0.225	19.0
180	194.7	13.24	3.64	38.8	38.10	0.166	46.05	52.95	0.201	0.231	19.3
190	204.7	13.92	3.73	40.1	38.80	0.169	47.16	54.22	0.206	0.236	19.5
200	214.7	14.60	3.82	41.4	39.50	0.172	48.18	55.39	0.210	0.241	20.1
210	224.7	15.28	3.91	42.8	40.10	0.174	49.35	56.70	0.216	0.247	
220	234.7	15.96	3.99	44.0	40.70	0.177	50.30	57.70	0.220	0.252	
230	244.7	16.64	4.08	45.3	41.30	0.180	51.30	59.10	0.224	0.257	
240	254.7	17.32	4.17	46.6	41.90	0.183	52.25	60.10	0.228	0.262	
250	264.7	18.00	4.24	47.6	42.70	0.186	52.84	60.76	0.230	0.264	
260	274.7	18.68	4.32	48.8	43.00	0.188	53.85	62.05	0.235	0.270	
270	284.7	19.36	4.40	50.0	43.50	0.190	54.60	62.90	0.238	0.274	
280	294.7	20.04	4.48	51.1	44.00	0.192	55.50	63.85	0.242	0.278	
290	304.7	20.72	4.55	52.2	44.50	0.194	56.20	64.75	0.246	0.282	
300	314.7	21.40	4.63	53.4	45.80	0.197	56.70	65.20	0.247	0.283	
350	364.7	24.80	4.98	58.5	47.30	0.206	60.15	69.16	0.262	0.301	
400	414.7	28.20	5.31	63.3	49.20	0.214	63.19	72.65	0.276	0.317	
450	464.7	31.60	5.61	67.8	51.20	0.223	65.93	75.81	0.287	0.329	
500	514.7	35.01	5.91	72.1	52.70	0.229	68.46	78.72	0.296	0.342	

TABLE II. *See page* 5110.

miles deep. In the afternoon Dr. Raymond repeated that delightful and instructive address which he gave on Jamaica at the New Haven meeting of the Institute. As Jamaica was en route every one was eager to get information about the Island from one who had spent so much time there.

The first session of the Institute was held on the ship the afternoon of October 24. President Brunton welcomed the members and said that the Institute was to be congratulated not only on the large number present, but especially in that there had never before been so representative a gathering of the prominent and distinguished men of the mining industries. Dr. Raymond read by title only a long list of papers, giving notice that some of them would be taken up and read or discussed at future meetings of the Institute.

A general discussion was held on the extinguishing of mine fires. Mr. William A. Lathrop introduced the subject by referring to the fire at the Summit Hill mine of the Lehigh Coal & Navigation Company. Mr. Warriner, formerly General Manager of the Calumet & Hecla mines, explained how the fire in the Calumet & Hecla was extinguished. Mr. R. V. Norris described the fire at the Lykens Colliery, and W. J. Richards called attention to the fact that shutting off the air is sometimes more effective in putting out a mine fire than flooding by water. Mr. Samuel A. Taylor referred to certain fires in the Wyoming field which had been caused by crossing of the electric wires. President Brunton spoke of the great fire at the Anaconda Mine, it being generally known that Mr. Brunton's skill contributed very largely toward the control of this fire. He described how futile were the attempts to extinguish the fire by water, and it was only by building bulkheads at intervals closer and closer to the fire that the territory was brought under control.

An interesting feature of Mr. Brunton's remarks was the description of how the men wore helmets, to which they attached hose which was connected with the regular compressed air pipe in the mine, this air not only serving to keep down the temperature, but to blow away the smoke and noxious gases, enabling the men to reach places in the mine

otherwise inaccessible. At these places stone walls were built blocking off the air. Mr. Brunton said that the men got so accustomed to the use of these air helmets that it was a common remark that with such an equipment a man might build a stone wall around Hell. In the evening a general entertainment was given in the music room, followed by dancing.

So favorable had been the weather that the ship arrived in Havana early on Tuesday, the 25th, being so much ahead of time that the party of Cuban engineers who had planned to receive us were not on hand. A reception was given at the Plaza Hotel in the afternoon. On arriving in Havana a party of enthusiastic mining engineers hired a cab and told the driver to show them the town. He went straight to the big hill back of Havana and pointed out the beautiful panoramic view of the city and harbor. Going on a little further he stopped in front of a stone mansion where armed guards were marching, and exclaimed, "Presidio." "Ah," said an M. E. who prided himself on his Spanish, "yes, this is the residence of the President,—presidio, I know. What a beautiful spot and what a substantial mass of buildings!" In the evening of the same day this party was received by President Gomez, and for the first time learned from the President himself that the presidio was the penitentiary. The impression made upon every one was that Havana could no longer be looked upon as a dirty city; that it was distinctly clean and healthy. Little evidence was seen of the hurricane, which had done its greatest damage in the interior by the destruction of tobacco.

On Thursday, the 27th, en route to Jamaica, the Institute held a session on the ship, continuing the discussion on mine fires. This was participated in by Mr. Norris and Mr. Kelly. Mr. Kelly described four cases of fire, referred to the use of the fire helmet, and said that he had learned as soon as an alarm of fire was sounded to first get the men out of the mine and next not to use candles but acetylene lamps. Prof. Brunton said that in his experience with carbon-monoxide in mines there was a note of alarm sounded when the danger point was reached, this being a tickling sensation in the forearm or in the legs, or both, and that as soon as this sensation is felt one should get out of the mine as quickly as possible. Dr. Raymond read a letter from E. E. Ludlow about an explosion in the Pelawo mine in Mexico. Mr. Parker in discussing this case said that the explosion was probably due to the powder used,—a cheap dynamite, not one of the explosives known as permissible in the United States Government regulations, and that all coal in this mine was shot from the solid, no undercutting being done. Prof. Brunton spoke of the effect of putting water in contact with certain sulphur ores in mine fires as resulting in greater heat, thus being ineffective in extinguishing a fire. Gardner Williams described the great mine fire at the De Beers, where 202 persons were killed. Hennen Jennings was introduced by Dr. Raymond as a man who had never had any mine fires. Mr. Jennings said that the conditions in the Johannesburg mines were essentially safe, little or no timber being used; that these mines had produced nearly three hundred million pounds of Sterling in gold, and that his story about mines fires would have to be like the treatise which the man wrote on the snakes in Ireland; namely, there are no snakes in Ireland.

In the morning, Friday the 28th, the entire party indulged in sports. Sober men, who carry responsibilities at home, could be seen in their shirt sleeves doing cock fights across a spar which the Captain had strapped above the deck; indulging in pillow fights, races and a general tug-of-war. Another session of the Institute was held in the afternoon, Prof. Richards, of Lehigh, read a paper on the Production of Pig Iron by the Electric Furnace in Sweden. Sports continued in the afternoon, the old watchman, a black, Jamaica negro, dancing a jig to the amusement of the passengers and to his own utter demoralization by being in the presence of such an audience. A concert was held in the evening, the Jackdaw of Reims being read and an original poem a la Ingoldsby Legends by Dr. Raymond. Saturday and Sunday, the 29th and 30th, were spent at Jamaica. Much of the enjoyment at Jamaica was due to the courtesy of Mr. Meyer, the General Passenger Agent of the Hamburg Line, who accompanied the party throughout the trip, and to Captain Forward, the agent at Jamaica. The natural scenery of this island is so striking,

Horsepower Required for Compressing One Cubic Foot of Free Air per Minute (Isothermally and Adiabatically) from Atmospheric Pressure (14.7 pounds) to Various Gage Pressures.

Three-Stage Compression.

Initial Temperature of Air Taken as 60°F.—Jacket-Cooling not considered

Gage Pressure, Pounds	Absolute Pressure, Pounds	Number of Atmospheres	Correct Ratio of Cylinder Volumes	Intercooler Gage Pressures—First and Second Stages	Isothermal Compression: Mean Effective Pressure	Isothermal Compression: Horsepower	Adiabatic Compression: Mean Eff. Pressure, Theoretical	Adiabatic Compression: Mean Eff. Pressure plus 15 per cent Friction	Adiabatic Compression: Horsepower, Theoretical	Adiabatic Compression: Horsepower plus 15 per cent Friction	Percentage of Saving over Two-Stage Compression
100	114.7	7.8	1.98	14.4 / 14.4	30.30	0.132	33.30	38.30	0.145	0.167	5.23
150	164.7	11.2	2.24	18.0 / 18.0	35.59	0.155	40.30	46.50	0.175	0.202	5.92
200	214.7	14.6	2.44	21.2 / 21.2	39.50	0.172	45.20	52.00	0.196	0.226	6.67
250	264.7	18.0	2.62	23.9 / 23.9	42.70	0.186	49.20	56.60	0.214	0.246	6.96
300	314.7	21.4	2.78	26.1 / 26.1	45.30	0.197	52.70	60.70	0.229	0.264	7.28
350	364.7	24.8	2.92	28.1 / 28.1	47.30	0.206	55.45	63.80	0.242	0.277	7.64
400	414.7	28.2	3.04	30.0 / 30.0	49.20	0.214	58.25	66.90	0.253	0.292	8.33
450	464.7	31.6	3.16	31.8 / 31.8	51.20	0.223	60.40	69.40	0.263	0.302	8.36
500	514.7	35.0	3.27	33.4 / 33.4	52.70	0.229	62.30	71.70	0.273	0.314	8.38
550	564.7	38.4	3.38	35.0 / 35.0	53.75	0.234	65.00	74.75	0.283	0.326	8.80
600	614.7	41.8	3.47	36.3 / 36.3	54.85	0.239	66.85	76.90	0.291	0.334	8.86
650	664.7	45.2	3.56	37.3 / 37.3	56.00	0.244	67.90	78.15	0.296	0.340	9.02
700	714.7	48.6	3.65	38.3 / 38.3	57.15	0.249	69.40	79.85	0.303	0.348	9.18
750	764.7	52.0	3.73	39.2 / 39.2	58.10	0.253	70.75	81.40	0.309	0.355	
800	814.7	55.4	3.82	40.1 / 40.1	59.00	0.257	72.45	83.25	0.315	0.362	
850	864.7	58.8	3.89	40.9 / 40.9	60.20	0.262	73.75	84.90	0.321	0.369	
900	914.7	62.2	3.95	41.7 / 41.7	60.80	0.265	74.80	86.00	0.326	0.375	
950	964.7	65.6	4.03	42.4 / 42.4	61.72	0.269	76.10	87.50	0.331	0.381	
1000	1014.7	69.0	4.11	43.1 / 43.1	62.40	0.272	77.20	88.80	0.336	0.383	
1050	1064.7	72.4	4.15	43.7 / 43.7	63.10	0.275	78.10	90.10	0.340	0.391	
1100	1114.7	75.8	4.23	44.3 / 44.3	63.80	0.278	79.10	91.10	0.344	0.396	
1150	1164.7	79.2	4.30	44.8 / 44.8	64.40	0.281	80.15	92.20	0.349	0.401	
1200	1214.7	82.6	4.33	45.3 / 45.3	65.00	0.283	81.00	93.15	0.353	0.405	
1250	1264.7	86.0	4.42	45.8 / 45.8	65.60	0.286	82.00	94.30	0.357	0.411	
1300	1314.7	89.4	4.48	46.3 / 46.3	66.30	0.289	82.90	95.30	0.362	0.416	
1350	1364.7	92.8	4.53	46.8 / 46.8	66.70	0.291	84.00	96.60	0.366	0.421	
1400	1414.7	96.2	4.58	47.2 / 47.2	67.30	0.293	84.60	97.30	0.368	0.423	
1450	1464.7	99.6	4.64	47.6 / 47.6	67.70	0.295	85.30	98.20	0.371	0.426	
1500	1514.7	103.0	4.69	48.0 / 48.0	68.30	0.298	85.80	98.80	0.374	0.430	
1550	1564.7	106.4	4.74	48.3 / 48.3	68.80	0.300	86.80	99.85	0.378	0.434	
1600	1614.7	109.8	4.79	48.6 / 48.6	69.10	0.302	87.60	100.8	0.382	0.438	

TABLE III. *See page* 5110.

its history so unique, and the natives so simple, yet polite, clean and intelligent, that one is well repaid by a visit. Parties going to the Canal Zone would do well to stop en route at this interesting island, some of the mountain peaks of which are nearly a mile and a half high. The effects of the earthquakes are visible throughout Kingston, especially at that interesting city, Port Royal, once known as the wickedest city in the world.

From Jamaica to Colon is a two-day trip. The party was entertained en route by a parade of the "Kingston missfits" and other sports. The weather had become so warm that many availed themselves of the opportunity to purchase light suits of clothing at Kingston. Another session of the Institute was held on Monday, and a general history and description of the Panama Canal was given by the writer, followed by an interesting address on Panama and its people by Mr. John M. Sherrerd. On the evening prior to arrival at Colon the Captain's dinner was held, being rather unexpected, and as the passengers were in their shirt sleeves, because of the warm weather, a committee was appointed to ask the Captain about the formalities of the occasion. His reply was characteristic: "Do as you like, gentlemen, this ship is for the passengers, not the passengers for the ship."

Arrangements had been made to visit the Gatun Dam on November the 1st, the day of arrival at Colon, but the ship's engine went wrong during the night, or, as stated on the blackboard the next day, "The fly wheel jumped over the eccentric," hence the arrival at Colon was too late to follow the program, the party being met by Col. Goethals and Admiral Rousseau, who took the train directly to Panama. This journey gave the first general view of the Canal, as the railroad follows the line closely. The cars are comfortable, an observation car being carried at the rear. The first impression made upon one who had visited the Isthmus before was that great progress had been made in and about Gatun, and next it was plain that Gatun Lake was already a reality, for along the line for miles the train followed through swampy places, the water at times being over the rails, conditions that had not before been seen by one who was over the line three years ago.

This water was the backing up of the lake behind that portion of the Gatun Dam already finished, the limitation, as Col. Goethal explained, being the height of the spillway gates through which a torrent of water ran below the dam. A part of this journey from Colon to Panama was over the re-located line of the Panama Railroad. This line has been relocated throughout its entire length, though much work has yet to be done upon it. A high tribute was paid to John F. Stevens by Col. Goethals, who said that the army engineers now building the Canal were not railway builders, but that Stevens had left them an inheritance in this relocation of the Panama Railroad which was very much appreciated, and which had aided so much in carrying out the general plan of the work.

Through the courtesy of the engineers a special train took us through the Culebra Cut on November the 2nd. The story was told of a Congressman who was taken to the bottom of the Gatun locks and looking upward through that immense gorge between masonry walls he said to Col. Goethals, "At last I may now say that I stood on the bottom of Culebra Cut. Will you now please show me the Gatun Dam." The Culebra Cut, as we saw it, resembles a canyon in Colorado. It is about eight miles in length and has been excavated at each end to within about five feet of completion. In the middle seventy feet more in depth has to be taken out. The walls on either side rise in varying slopes to a height of about 400 feet. Huge slides are in evidence, one of them reaching back 1,400 feet from the cut, the material in this slide being estimated at three million cubic yards. These slides are gradual in movement, though occasionally a heavy and rapid fall of material takes place, one of these slides having submerged a steam shovel. The material of the Culebra Cut is the most unusual conglomeration of basaltic and sedimentary rock that has ever been seen in one place. It varies in color, hardness and in chemical composition, these variations taking place at frequent intervals. No man can estimate when or where a slide will occur or how much material will work its way into the cut before it reaches the angle of rest. Col. Goethals in answer to the question, "What is the angle of rest?" said that the material had not stood still long enough for them to measure it and that it varied all the way from zero to 90 degrees. One could not stand at the bottom of this cut and view the uncertainties of the situation without reaching the conclusion that to deepen the Canal eighty-five feet more might involve difficulties and delays beyond calculation. From the nature of the material it would seem that when the water is in the cut it will aid in holding it in place, and the plan which is being followed is to let it slide as it will, removing it with shovels until it reaches its level. This will probably go on after the Canal is finished, but the dredges will then be able to take care of the surplus material even better than the steam shovels.

The party were entertained at a reception given by the President of Panama, Senor Arosemena, a genial Panamanian, dark enough in complexion to indicate the presence of Indian blood, democratic to an extreme and proud of the Canal and his country. November the 3rd being the anniversary of the independence of Panama, we had the pleasure of seeing a renewal of the old Fourth of July fireworks system, which is becoming obsolete in the United States. The President reviewed the army from the balcony of his residence. This army is nothing more than the police force, consisting of fifty men, quite sufficient to protect a country which is under the surveillance of the United States. Here we have an allustration of the practical nature of the Monroe Doctrine when applied to a Central or South American republic. They save enormous expenditures of money by devoting their time and attention, and the funds of the state, to causes other than defense, depending entirely upon the United States to protect them against enemies within and without. An opera party at the National Theater in the evening was a pleasant diversion. This theater is maintained by the government, the players being brought over from Spain at the government's expense; a nominal fee only is charged for admission.

On November the 4th an evening session of the Institute was held at the Tivoli Hotel, where Dr. Gorgas described the work of sanitation which has accomplished so much on the Isthmus and at Havana. The Doctor gave a few instances of the conditions that existed on the Canal under the French. He said that three out of every four Frenchmen who came to build the Canal died of yellow fever or

some other disease; that of twenty-four Sisters of Charity who came there as nurses, only two survived; that a French Director General lost through yellow fever every member of his family, consisting of his wife and three children, he himself becoming insane. He described in detail the sanitation of the city of Panama, which had been known throughout the world as one of the most unhealthy cities. Each residence formerly had a cistern to catch rain water for drinking purposes. The water in these cisterns bred mosquitoes, which transmitted yellow fever and malaria. The yellow fever mosquito is a different mosquito from the malaria mosquito. The yellow fever mosquito is invariably a female. She cannot transmit disease until she herself has taken it, but after a certain period the mosquito becomes infected with yellow fever and transmits it to others. This mosquito is domestic in its nature and does not fly far from its place of birth. Were it otherwise, Dr. Gorges said, the yellow fever mosquito might almost exterminate the human race.

Dr. Hayes, of the United States Geological Survey, talked on the subject of the geology of the Isthmus, and Gardner Williams showed lantern slides of the diamond and gold mines in South Africa.

November 5 was a day of play and excursions to Taboga Island, a beautiful spot in the Pacific Ocean, near the entrance of the Canal. In the evening the Institute gave a reception with dancing and a supper. This was attended by the English, French and other ministers, by prominent Panamanians with their wives and daughters, and by the officers and families of the Canal service. Col. Goethals, Dr. Gorgas with wife and daughter, Col. Seibert, Gov. Thatcher, the Civil Administrator of the Canal Zone, Admiral Rousseau, and others were present. Mr. Campbell, the American Charge d'Affaires, assisted in this reception. The sensitive nature of the native Panamanians was shown by the fact that at the conclusion of the dances the orchestra played the Panama national hymn, to which two or three persons danced, very much to the indignation of the Panamanian ladies.

On Sunday the hospital at Ancon was visited. No one can see this hospital without admiring its equipment, the skill of those in charge of it and the beneficient influence to those not only on the Isthmus but throughout Central and South America. Pilgrimages are made to Ancon Hospital and large sums paid to the government for surgical operations and treatment there. An evening session was held, in which Mr. Parker read a paper on Coal Mining Machinery, illustrated with lantern slides. Mr. Rushmore illustrated electrical devices, and Mr. Gardner Williams told the story of Rhodes and the development of South Africa, with some splendid views of the country, the men and the animals.

On November 7 the Gatun Dam and locks were inspected, occupying the entire day. Though this was the rainy season there had been little rain on the Pacific end of the Canal. Statements were made that the rainfall on the Pacific end is only half as great as that on the Atlantic end. This was verified when the party reached Gatun, where there was a baptism of rain which fell at the rate of 3.28 inches in 59 minutes. Forty-two per cent. of the lock work on the Atlantic end has been completed and fifteen per cent. of the work on the Pacific end. About one-third of the Gatun Dam is finished. The toe-walls, consisting of dumps of broken rock about one-quarter of a mile apart, are plainly in evidence, the loose material being pumped in between. This material hardens when it settles, and it would seem to form an impervious bed for the dam. The material is being pumped into the dam at the rate of 550,000 cubic yards per month, the entire volume of the dam being twenty-three million yards.

The figures show that concrete is being laid on the Pacific end at $4.65 per yard, a figure unusually low, but the conditions there are very favorable, the stone being brought from the Ancon quarries close at hand, grades are favorable and the sand coming from the Pacific end. The concrete costs about $2 in excess of these figures at the Atlantic end. To explain this the statement was made that the work is done in eight-hour shifts on the Pacific end and in twelve-hour shifts on the Atlantic. These eight-hour shifts split up the work and effect economies of operation. Cantilevers are used on the Pacific end and cable-ways on the Atlantic, it being claimed that the cantilevers effect economies in transportation of the material. Wood forms are

used on the Pacific end, steel forms on the Atlantic. It is questionable whether the steel forms give any advantage over the wood, as they are very expensive; hence there is not a surplus at hand to give elasticity in movement from one place to another, the forms being left in place until the cement is set. Furthermore, the steel forms do not adapt themselves so well to varying conditions.

At the Atlantic end the stone for the concrete cost $2.40 per yard in the stock pile. Of this $1.10 is amortization of the plant, tugs, etc. This is a heavy amortization due to the fact that the quarries are at Porto Bello, requiring a large equipment of scows and tugs and double handling of material. At the Pacific end the material is brought down grade from the quarry in cars and delivered, directly to the concrete mixer, hence there is little or no amortization charge against the cost of the stone in the Pacific end, which is said to be 80 cents per yard in the stock pile. Another point which must not be lost sight of is that the weather, not only in the storms at sea, but in the rainfall, is worse on the Atlantic than on the Pacific end. The figures appear to show but little difference in cost of concrete when based upon taking the stone and sand from the stock pile and mixing and placing. Even with the added cost on the Atlantic end the figures compare favorably with those given for concrete on the New York Barge Canal, which is said to be $7.34 per yard.

The figures show that rock is being removed on the Canal for about 50 cents per cubic yard in the dry. This cost, however, does not include administration expenses, which would bring it up to about 70 cents. The removal of rock under water by the drill scow and by the Lobnitz system is said to cost somewhere between $1 and $2 per cubic yard, the figures not being accurately determined because insufficient dredging has been done so far. Both systems appear to have a place on this work, the drill scow for heavy cutting and the Lobnitz for light work at a depth of 2 or 3 feet. The submarine rock excavation has been reduced to something like 150,000 yards by the plans which are being carried out of coffer-damming the work, hydraulicing the material over the rock and pumping it into the dam, removing the rock in the dry.

To sum up, it is plain that the Canal is being built expeditiously on plans which are wise and with an organization that is well fitted to carry out these plans. Recent floods have deposited hundreds of thousands of yards of gravel at the mouth of the Chagres River, thus contradicting the arguments made by the sea level advocates, that the Chagres was not a sediment carrying stream. This sedimentary material is in evidence everywhere, being used in the towns for road building. It consists mainly of pebbles. With the enlargement of the mouth of the Chagres by the Gatun Lake, which carries the waters of the lake ten miles up the river, it is not likely that this material will be a menace to the Canal.

The work of excavation is nearly three-quarters done, but no attempt is made to finish the excavation in advance of the work on the Atlantic end, the plans following a system of coordination of work from one end of the Isthmus to the other. That the Canal will be finished some time during the year 1914 there appears to be no reason to doubt.

The Hotel Tivoli at Panama is a first-class hostelry on a hill facing the Pacific, beautiful in its surroundings and comfortable, notwithstanding the difficulties which must accompany an effort to give food and service to those who are accustomed to hotels in the North. The food is drawn from the government commissariat; vegetables are not raised on the Isthmus and chickens are scarce, hence everything is imported. The waiters are easy-going West Indians, some good and some bad and others very bad. Mrs. William Kelly was greeted by a Tivoli waiter, who put a finger bowl in front of her with the exclamation, "Wash your fingers, miss." This same waiter was transferred to Gatun when the party was given a luncheon, and recognizing Mrs. Kelly he apologized for the absence of finger bowls by giving her a soup bowl to "wash her fingers in."

The party left the Isthmus on the 8th and were loudly cheered. It was not explained whether this cheer was a compliment or otherwise. It was said that a delegation of Congressmen were also cheered and that a man on the dock was heard to exclaim: "The Lord gave and the Lord hath taken away, blessed be the name of the Lord."

As the ship was warped from the dock the

songs went over the water: "Here's to Col. Goethals, may Culebra Cut have no falls."

Homeward bound the party held an election for Governor of New York, resulting in a majority for Mr. Stimson, Captain Krause assuring us that never had his passengers failed to correctly indicate the result of the elections.

Sessions of the Institute were resumed, the subject of discussion being the Panama Canal where a uniform sentiment of approval was shown. This was embodied in a signed statement which has already been published.

November 10 was spent at Kingston, Jamaica, where the party took lunch at the Myrtle Bank Hotel on the invitation of President Brunton, who received his reward in cheers for "Baby Brunton whose daddy went a'hunting." It was moved, seconded, and unanimously adopted, that Brunton be continued as President of the Institute until the completion of the Canal. An enthusiastic member moved as an amendment, that "Judgment Day" be substituted for "Canal." We were honored by a visit from a German Prince, the nephew of the Emperor, and an alligator. The Prince being in Kingston Harbor on a German warship, and having shot an alligator he wanted it despatched home, so took advantage of the sailing of the August Wilhelm.

Sessions of the Institute were continued, a paper was read by Mr. Goodale, of Butte, on the Utilization of Electric Power. He explained the system being installed there by which power at 110,000 volts is taken 132 miles to Butte, where it is to be converted into compressed air for running thirty hoists, all situated within one and a half miles, the plant being located in the center of the district. Mr. Watson described the Taylor system of compressing air which is in use at Cobalt and said that they had found that this air contained less oxygen than normal compressed air, the effect being such as to prevent the use of candle in the mines, and that at times if the air is drawn on rapidly moisture is carried over with the air. The last stopping point, before reaching New York, was Fortune Island, where thirty-eight negroes, known as deckers, were put ashore, these men having been taken on only for the purpose of handling freight. Fortune Island is a narrow strip, about a mile wide and several miles long. It belongs to the British Bahama Group and is peopled by negroes. The Governor of the Island, a white man, came aboard and was asked if there were any white people on the Island. He replied "Yes," and pointing to a dark-skinned companion, he said, "I and the postmaster there." It seems that this governor has lived on the Island almost a lifetime. He lost his first wife and has recently married again. Captain Krause told us of the exuberant joy with which the Governor greeted him recently, saying that "I have got a fine wife now, Captain. She weighs 250 pounds."

The President of the United States was on his way to the Canal while this ship was en route North, hence a wireless was sent into the air as follows: "American Mining Engineers returning from Isthmus congratulate you upon good plan, splendid management and satisfactory condition of work." To this came the following reply:

"Your message received. It is most satisfactory to have the assurance of men who are experts that the great Canal construction has been well planned and is being carried on to a successful completion. I thank you for this visit and the courtesy of your kind message. Taft."

To pass a President of the United States was an era in the good record of Captain Krause, who bore on his breast a medal from the old German Emperor for saving a life and the Honor of the Golden Cross from the present Emperor for saving a ship, so when these wireless messages were received this gallant captain slept not at all. Disregarding the compass he veered his ship landward, and as became an old mariner, he figured the time and place when the Prinz August Wilhelm might pass the two warships bearing the President of the United States. About two dozen passengers kept company; instilled with the same spirit, paced the deck, straining their eyes landward in the cold moonlight, hoping to catch a glimpse of the President. All at once there was a sound of revelry on board, men ran about the decks, the halyards rattled, and at the sound of the Captain's whistle the port side of the ship was ablaze with red, white and blue lights, discharged at intervals from each deck and from many portholes. The wireless man was also put in action, sending his sputtering notes and lightning flashes

at the foremast. It was indeed a sight that "left itself forever on your mind." But the land lovers who stood up to see this failed to recognize a thing but the pale moon and its streaks across the water. "See it there," said the Captain, "right under the moon." Time passed, the lights went out, quiet was restored, when the watch in the crow's nest sent the signal soon plain to everybody, that over the starboard quarter came two mammouth warships bearing the President, and the good Captain confessed that he had saluted a coal hulk bearing its load of Pocahontas down to the Isthmus. The Captain was sure that the coal hulk responded to the signals as he saw something "going up" in the air in the light of the flashes from the August Wilhelm. Imagination only can picture the exultation on the deck of the coal hulk, and the things that went up were doubtless chunks of best coal, thrown mastward in acknowledgment and appreciation of the noble salute. The log of no coal hulk ever before recorded such a history.

The sessions of the Institute were continued. Mr. Ayres presenting his paper, Conservation of Coal and Its Production for Market. President Brunton read a report of the Thirtieth Annual Convention of the American Mining Congress which was held at Los Angeles, Cal., September 26, 1910. Mr. Taylor presented a report of the Mining Congress on rules governing the installation of electricity in mines, referring briefly to a report in detail which would be presented and printed in the transactions of the Institute. Dr. Raymond read a letter from Prof. Edw. H. Williams, Jr., of Woodstock, Vt., in regard to the proposed mining laws. The printed report of the Committee on Uniform Mining Laws for the Prevention of Mine Accidents was discussed by Mr. George H. Warren, Mr. Kirchhoff, Mr. McAuliffe, Mr. Warriner and Mr. Jennings. Mr. Jennings dwelt particularly on the question of secrecy and said that the true policy of a mining company, like the true policy of any company presenting its stock for sale on the market, should be to give the public all information available concerning the mine, the costs included. He said, "If we desire or demand the open shop we should give an open office. This hushed, underbreath talk about mines only hurts the industry and helps the swindler." Messrs. Goodale, Kelly and Watson also joined in the discussion. Mr. Gardner Williams said that in English countries the regard for law and the enforcement of law is very much greater than in the United States.

On Sunday the 13th services were held by Dr. Raymond in the morning. Robt. P. Porter, representating the London Times, addressed the Institute upon South America, and the evening was given up to an enthusiastic celebration of the birthday of Dr. Joseph Struthers, who while not the master of the ship was surely the master of the trip. To Dr. Struthers, more than to any other one person, belongs the credit for the success of the meeting.

On the 14th sessions of the Institute were continued. Dr. Raymond read a paper expressing approval of the plan of work of the Panama Canal, which after amendment, was unanimously adopted. Prof. Richards addressed the Institute on the Electrical Manufacture of Steel, and the President adjourned the meeting with congratulations for an experience which can only be characterized as one continuous carnival of pleasure and interest.

W. L. SAUNDERS.

COMPRESSED AIR ON THE PANAMA CANAL

From the report of the Isthmian Canal Commission for the year ending June, 1910, we learn that the air compressor subdivision compressed during the year 7,227,203,513 cubic feet of free air, as against 4,935,110,000 cubic feet for the preceding year, an increase of 46 per cent. Two additional compressors of 2,500 cubic feet free air capacity were installed. All compressor plants have been equipped with hot water meters, fuel oil heaters and other accessories for keeping close accounting of the output per barrel of fuel oil, of water evaporated per barrel of oil and the general economies of plant operation.

On account of slides occurring in Culebra cut, 18,810 feet of main pipe line were removed and relaid. Also 3,000 feet of 8 inch main pipe was installed between Balboa plant an Ancon rock crushing plant. During the year, in furnishing air connections for drills and other purposes, 1,838,128 feet (348 miles) of pipe was laid, 3,040 feet of pipe was repaired.

COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

Established 1896

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AIR COMPRESSOR DEVELOPMENT

It has often been remarked that those most intimately responsible for compressed air practice, in the designing of apparatus and in the installation and operation of air plants, have been neglectful of the possible efficiencies, so that, up to very recently, compressed air as a means of general power transmission has been dicredited and its adoption in many cases has been delayed by the prevalence of unnecessarily wasteful practices which have operated as deterrent examples. In recent years there has been an encouraging change for the better in this particular, so that now it may be said that much of the air used is compressed at one third of the actual power cost, with commensurate reductions also in labor and other accompanying items, as composed with the costs of less than a score of years ago. It is no wonder that it is found out at last that it will pay to use compressed air in large and more or less permanent engineering operations, where it would not have been thought of when air first began to be compulsorily used for mining and tunneling and subaqueous work, the possible economies in practice being then so generally ignored.

We may gather what consolation we can from the fact that steam economy developed even more slowly than that of compressed air. From the Great Eastern to the Campania there was an interval of forty years, the former having 8,000 horsepower and the latter 30,000 upon practically the same coal consumption. In the successive trans-Atlantic steamers which came out in the meantime, each at the time represented the best skill and judgement of its designers, but the same could hardly have been said of air compressors until very recent years. The standard compressor and practically the only compressor of the leading builders less than a score of years ago had a single steam cylinder and a single air cylinder, thus ignoring the even then well known possibilities of economising at each end of he machine.

The attention of the engineering world was at this time being especially directed to the possibilities of steam economy by the various reports of tests of pumping engines in the Transactions of the Mechanical Engineers and elsewhere, so that there would seem to have been special suggestion and incentive to consider and adopt similar economies in com-

pressed air practice. The possible explanation of the failure to do so may be two-fold. The water pumping problem is a vastly simpler one than that of air compression; indeed, there would seem to be no easier proposition for the steam engineer than the high duty pump, while that of the air compressor is among the most complex and difficult.

In the pumping engine the work is continuous. The machine may run day and night, and always at its best, without a governor and without change of adjustment. The resistance agaist the piston is constant for the entire stroke, and the same for every stroke, and there is no such thing even as clearance to be thought, the pump being its own meter, its count of strokes being its record of delivery.

In the air compressor the work is never constant, because the rate of consumption is constantly varying and the air can be stored in advance only in comparatively small volume. In the compressing cylinder a constantly increasing resistance opposes a constantly diminishing steam pressure. Clearance cannot be all eliminated and whatever there is represents reduced capacity. The heating of the air during compression necessitates the cooling of the working surfaces to secure safe lubrication, and the keeping of the air itself as cool as possible is a necessary expedient in the saving of power. While water may be pumped to any pressure in a single cylinder, air must be compressed in stages with efficient cooling of it between them. To control the intake and delivery of the air to correspond with the rate of consumption and at the same time keep the compressor in reliable and economical operation has challenged the ingenuity of the best engineers, with results now most satisfactory.

In the designing and in the operating of the steam driven air compressor all the conditions, at both ends, or in the operation of both functions of the machine, are to be considered. Comparing the best and recent practice with what was only lately too prevalent, it is found, after all, that considerably more is to be saved at the steam end than at the air end of the machine, and those who have had the most to say about the economy of, say, two-stage air compression for the usual working pressures, while ignoring the possible steam economies for the same machines have not been true missionaries.

Of course the complete, self-contained and up-to-date machine, which embodies all that is best in capacity, efficiency, economy and reliability is not the cheapest to build, nor the machine easiest to sell to the uninformed, and the temptation to build the cheap and inefficient has too often prevailed, but now customers are being educated, and especially the best enigneers are becoming alert and are seizing their opportunities, and large permanent plants embodying all that skill can design and capital command are becoming frequent.

NEW BOOK

Rock Drills, Design, Construction and Use. By Eustace M. Weston. McGraw-Hill Book Company, New York. 370 pages, 6x9 inches, 193 cuts and numerous tables. Price, $4.00.

The author of the book is an Associate of the School of Mines, Ballarat, Australia, and a Lecturer on Mining in the Transvaal University College. He has had practical mining experience in Australia, South Africa and the United States and his book throughout bears evidence of complete familiarity with its subject. The various makes of both piston and hammer drills are described, with notable omissions of one or two of the most prominent of the latter class. The largest part of the book is devoted to rock drill practice and to mining and tunneling in general. Numerous examples from actual practice under widely diversified conditions are given with detailed information of actual results secured.

A TWO CYLINDER SINGLE-ACTING AIR COMPRESSOR

[We reproduce here, complete, from *The Engineer,* London, cuts and description of a small air compressor, said to be an example of good engineering practice and design. It is not good practice to compress by single-stage to 100 lbs. Water jacketing of cylinders and heads merely keeps the metal cool and does little to cool the air during compression, so that the two cylinders instead of one give little advantage in this respect. Volumetric efficiency minutely greater or less is scarcely worth talking about for compressors whose maximum capacity is, say, 50 cubic feet of free air per minute, although if it were 5000 cubic feet it might be proper to consider it. The mechanical instinct which would make small machines, especially if high

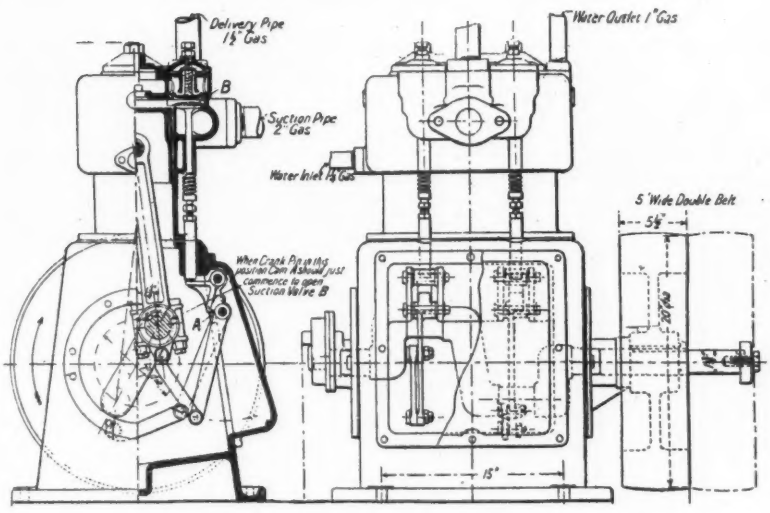

Delivery Pipe 1½" Gas
Water Outlet 1" Gas
B
Suction Pipe 2" Gas
Water Inlet ¼ Gas
5" Wide Double Belt
5½"
When Crank Pin is the position Cam A should just commence to open Suction Valve B
A
15"

FIG. 1.

speeds were desired, as simple as possible is still entitled to respect and does not lead to trouble.]

The ever-widening field of usefulness for compressed air is causing engineering firms to turn their attention to the production of compact and simple compressors to work at high speeds with efficiency. For the smaller machines two small single-acting cylinders are more efficient than a single cylinder, owing to the greater cooling surface they provide. The compressor of which we give an illustration in Fig. 1 herewith, is made by Broom and Wade, Limited, High Wycombe, and is an example of a modern single-acting machine in which good engineering practice and design have been embodied. This machine has two 6in. cylinders by 7in. stroke, and is fitted with a special form of automatic unloading valve, to which we shall allude later. The machine has been designed to compress air to 100 lb. pressure per square inch at one stage. The valves are mechanically operated, and the inlet valve is lifted by means of a special wiper and link off the connecting-rod. As will be seen in Fig. 2, the wiper works on a pallet with a rolling motion, closing and opening the valve noiselessly at the correct period of the stroke, the air flowing freely through the cylinder until the end of the stroke, and it is claimed that by means of its inertia the cylinder is filled with air at a pressure slightly above that of the atmosphere, thus increasing the volumetric efficiency. This method of operation increases the life of the valve and seat and ensures noiseless working. The valves are made of the finest nickel steel and are practically indestructible. The pistons are accurately

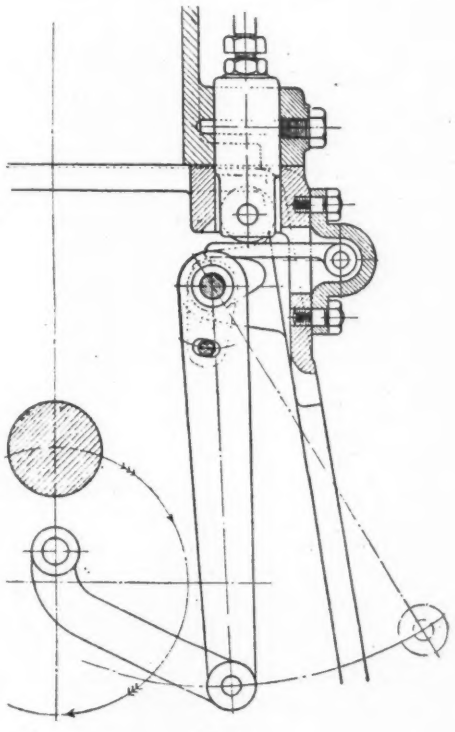


FIG. 2.

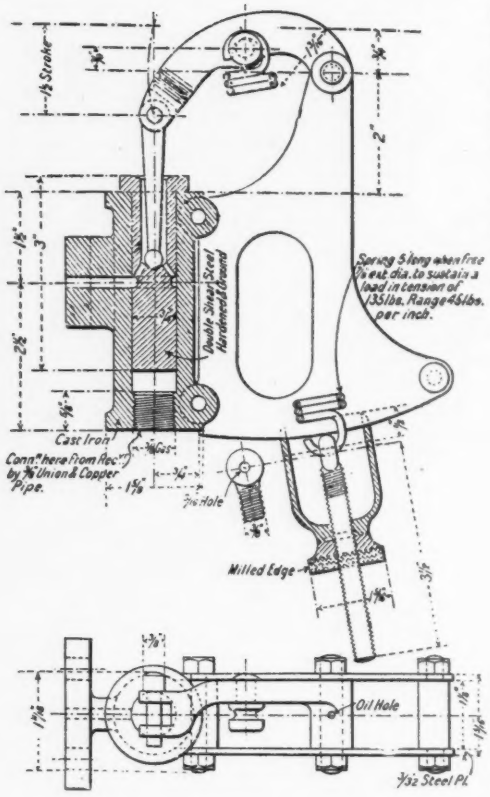

1½ Stroke
Spring 5 long when free ⅞ ext. dia. to sustain a load in tension of 135 lbs. Range 45 lbs. per inch.
Double Steel Hardened Ground
Cast Iron
Conn.ts here from Rec.r by The Union & Copper Pipe.
⅞ Hole
Milled Edge
Oil Hole
3/32 Steel Pl.

FIG. 3.

ground to fit the cylinders and are fitted with rings of a special type.

The bearings are lubricated by means of a rotary geared oil pump mounted on the end of the shaft. This pump has neither valves, plungers, nor eccentries to cause trouble. It is positive in action, and has only one pipe connection to the oil well in the base. It delivers oil through its own casing and a hole drilled through the crank shaft to each main bearing and to the gudgeon pin bearings. The cylinders are water-jacketed, and the cylinder casting is firmly secured to a heavy cast iron crank case, which also acts as the base of the machine and is provided with an oil well. The cranks are placed opposite one another, and the valve gear for each cylinder is operated by its own connecting-rod. Both the inlet and delivery valves are of ample area with only a small lift, and the delivery valve has a heavy spring which enables it to close quickly. Owing to these features, coupled with relatively small cylinders and large cooling surfaces, the volumetric efficiency of these two cylinder compressors is claimed to be greater than that of single-cylinder machines of the same capacity. Moreover, the whole of the cylinder head is available for cooling the air.

The automatic unloading device is mounted on the cylinder cover, and is independent of the rest of the machine. This appliance consists of a controlling valve—Fig. 3—which operates of its own accord when the receiver

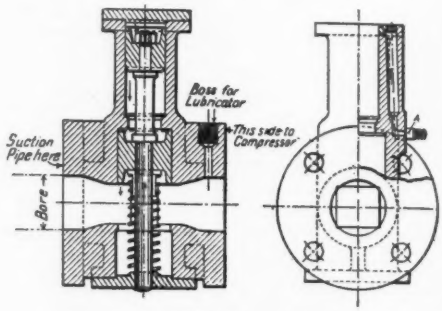


FIG. 4.

pressure rises to a fixed maximum or falls to a predetermined minimum. This valve in turn controls a piston-operated air inlet valve —Fig. 4—in such a way that when the pressure reaches the maximum the air supply is cut off and the compressor runs light. On the other hand, when the pressure has fallen to the minimum, the valve is opened and the compressor takes up its load again. The piston-operated inlet valve consists of a casing, provided with flanges, so that it may be mounted on the inlet supply pipe, and carrying a small air cylinder at its upper side. This cylinder has a piston, which is fixed on one end of an internal spindle, on which the piston valve is mounted. The piston and valve are normally kept in their upper open position by the helical spring shown. On the operation of the controlling valve, however, the upper end of the cylinder is put in communication with the air receiver, so that the pressure forces down the piston, overcomes the spring, and closes the piston valve. The working conditions remain thus until, owing to a fall of the receiver pressure, the controlling valve opens the cylinder in the inlet valve to the atmosphere, when the spring—Fig. 4—being no longer balanced by the pressure above the piston, extends, and opens the

valve again. Connection between the inlet valve cylinder and the automatic controlling valve is made by a small pipe, joined up to the air passage, shown in Fig. 3.

NOTES

According to a report made to the Geological Society of Mexico by Prof. Juan S. Agraz, a meteorite found on the Arenalas ranch, 88 km. northwest of Durango, contained: Iron, 96,60 per cent.; nickel, 0.99; cobalt, 2.39; carbon, 0.13. This is the first time carbon has been reported in any of the many meteorities found in Mexico.

The taxes on automobiles in Great Britain are determined according to the horsepower, on a rising scale. A car not over 6½ horsepower pays about $10 a year, while a machine of from 35 to 40 horsepower pays a trifle over $50, and one of from 40 to 60 horsepower, slightly over $100 a year. Automobiles with engines rated at over 60 horsepower are taxed at the rate of $202.70 a year.

For the 46 locks on the Panama canal, there will be 92 gate leaves. The leaves will be hung from the canal sides, meeting in the center when closed, and each leaf will weigh about 600 tons; will be 65 feet wide by 77 feet high and 7 feet thick; composed of girders and steel plating, with interior air chambers. The plating will be 7/16 inch thick at top, increasing to 13/16 at bottom.

A natural gas well of tremendous flow has been struck at Kessarmas, Hungary. The drill hole is 951 ft. deep and the flow of gas is about 31,782,600 cu. ft. per 24 hours. The gas carries about 99.25 per cent. of methane (CH_4) with a heat value of about 8,500 to 8,600 calories. The gas escapes from the drill with a velocity of about 420 miles per hour, causing a roar which can be heard about 2½ miles.

"The superstition with regard to the effect of water on the spine," says the Second Report of the Royal Commission on Mines, "does not appear yet to have entirely disappeared, according to Mr. E. B. Wain, who said that in Staffordshire the men still have a rooted objection to washing their backs, and we believe it lingers in others parts of the country. But, generally speaking, we believe that miners as a class are cleanly, and it must be remembered that in the case of men employed in severe manual exertion like hewing coal, often in a high temperature, perspiration acts as a cleansing agent; in fact, many miners may be said to take a daily Turkish bath."

The Hudson & Manhattan Railroad is now operating more than 2,200 trains a day in the tunnels under the Hudson River between New York, Jersey City and Hoboken. This is the largest number of trains operated daily on any double-track railroad in the world. During the rush hours the headway of trains in and out of the Cortlandt street terminal station is only 1 minute, and the maximum headway of trains between the hours of 6 a. m. and 12 midnight is 2½ minutes.

The amounts of air required in different portions of a mine, for ventilating purposes, are not apt to be supplied proportionally by the natural splitting of the currents. While the longer splits are likely to employ a larger number of men and accordingly require a greater quantity of fresh air, the natural division of the air would give them less and the shorter splits more than required. Accordingly, regulators are placed in the air ways to divide the current according to the demands of the different working places.

The Kruppe Works at Essen are growing as rapidly as ever. On July 1st of last year the firm employed 68,726 officials, clerks and workmen, who, with their families, made up the population of a large town; 37,761 were employed in the steel foundry and the gun-testing grounds alone. The coal and coke consumption amounted to 2,491,406 tons. The number of steam engines was 569, developing 89,430 horse-power. The firm has its own electricity works and gasworks, which latter produces 18,487,300 cubic metres of gas. There are 87 miles of railway, 52 locomotives, and 2,396 cars.

The bolometer, devised by the late Professor Langley to measure the heat of the stars, is a marvelous instrument. The heat of the

average star is no greater to us than the heat of a candle placed three miles away, yet this delicate instrument will measure the varying degrees of heat given off by different stars. A spider's web, a thread of spun glass, the gauze of a fly's wing and a mirror as small as a pin head, are some of the things that enter into its construction. It is so sensitive to heat that the image of a man's face thrown upon it at a distance of a half mile will be registered sharply.

The concrete pipe line just completed for the Ontario Power Company is declared to be unique in its engineering features among the great pipe lines of the continent. It is, in fact, the only one of its kind and size in the world. In diameter it is 18 feet, and a mile and a quarter in length. It took but five months to complete it. Resting on a solid foundation of concrete, it traverses a section of almost every known variety of soil. Rock, gravel, loam, and quicksand were encountered. The number of bags of cement used was 247,642, besides 2,350 tons of steel. Its walls are fully 18 inches in thickness. The big pipe could easily be used as an underground railway tube for an ordinary trolley or passenger train.

The perfilograph is an ingenious instrument for recording graphically the undulations of the bottom of a channel in depths to about six or seven fathoms. It is the invention of Augustus Mercau, an Argentine engineer, by whom a paper was read at Buenos Ayres before the Naval Section at the recent meeting of the International American Scientific Congress. A heavy weight of from 150 to 200 pounds is slowly dragged along the bottom by a wire rope attached to the stern of a steam launch. As the depth changes, the inclination of the wire varies. The sine of the angle made by the wire with the horizontal plane is registered graphically in parallel ordinates on a roll of paper which is slowly unwound by means of clockwork at a rate proportionate to that of the vessel.

The Missouri Sand Blast and Cleaning Co. of Chicago has recently made successful experiments in roughing the surfaces of sample concrete blocks, made from materials which are being used in the construction of a bridge at Lake Bluff, Ill. Experiments showed that a very good surface could be obtained in a short time with air at 50 to 55 lbs., and that best results are more easily obtained on concrete a month old or more than on green concrete. The proper surface cutting is obtained by holding the nozzle at an angle with the surface, and by varying the distance between the nozzle and the surface about 1,000 sq. ft. a day is easily covered, and with good men a maximum area of 2,000 sq. ft. could be done.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

NOVEMBER 1.

974,261. AIR-COMPRESSING APPARATUS. WILLIAM U. GRIFFITHS, Philadelphia, Pa.

974,267. DRILLING APPARATUS. JOHN J. HENNESSY and EDWARD A. CAPOCEFALO, Syracuse, N. Y.

1. A pneumatic apparatus comprising a case, an air compressing piston and a hammer piston movable in the case, the pistons being spaced apart therein and being unconnected, the spaces in the case behind the compressing piston and in front of the hammer piston being unconnected, and a catch extending through the case for holding the hammer piston in its retracted or starting position, during the compression stroke of the first mentioned piston, substantially as and for the purpose described.

974,286. VACUUM CLEANING APPARATUS. FRANK J. MATCHETTE, RICHARD RADDATZ, and CHARLES MOUKOS, Milwaukee, Wis.

974,328. FLUID-PRESSURE-CONTROLLED SWITCHING DEVICE. CHRISTIAN AALBORG, Wilkinsburg, Pa.

974,345. CENTRIFUGAL PUMP AND COMPRESSOR. HARRY F. BENSON, Lynn, Mass.

974,366. PUMP, INJECTOR, OR THE LIKE. GERHARD JOAN OTTO DORIS DIKKERS, Lonneker, near Hengelo, Netherlands.

974,375. FLUID-PRESSURE-ACTUATED IMPACT-TOOL. GEORGE H. GILMAN, Claremont, N. H.

974,409. COUPLING-VALVE FOR PNEUMATIC CLEANING-TOOLS. FRANK J. MATCHETTE and CHARLES MOUKOS, Milwaukee, Wis.

974,413. PRESSURE-FLUID ENGINE. HENRY H. MERCER, Claremont, N. H.

974,483. PNEUMATIC STACKER. JOHN GOODISON, Sarnia, Ontario, Canada.

974,540. SPRAYING APPARATUS. SAMUEL TRUDEAU, Toledo, Ohio.

974,543. FLUID-PRESSURE MOTOR. DANIEL SHAW WAUGH, Denver, Colo.

974,563. AUTOMATIC PRESSURE-CONTROLLER FOR WATER AND OTHER PIPES. IRA G. FOSLER, Chicago, Ill.

974,582. AIR-PUMP. JOHN J. MCINTYRE, Hartford, Conn.

974,617. RECEIVING APPARATUS FOR PNEUMATIC-DESPATCH SYSTEMS. HAROLD D. WATERHOUSE, Quincy, Mass.

974,618. SENDING MECHANISM FOR PNEUMATIC-DESPATCH APPARATUS. HAROLD D. WATERHOUSE, Quincy, Mass.

974,640. SPRAYING APPARATUS. MOTT BILLINGS BROOKS, Rochester, N. Y.

974,645. MINING-MACHINE. ALFRED U. DAVIS, Lutherville, Md.

974,743. PNEUMATIC THERMOSTAT. CHARLES E. BONNET, Philadelphia, Pa.

NOVEMBER 8.

974,789. OZONIZER. DAVID S. HENNEY, Newark, N. J.

974,795. CRUDE-OIL BURNER. LEE O. HUDSON, Altus, Okla.

974,799. PNEUMATIC-DESPATCH-TUBE APPARATUS. JOHN S. JACQUES, Hingham, Mass.

974,872. FLUID-PRESSURE VALVE. JOHN FOURNIA, Albany, N. Y.

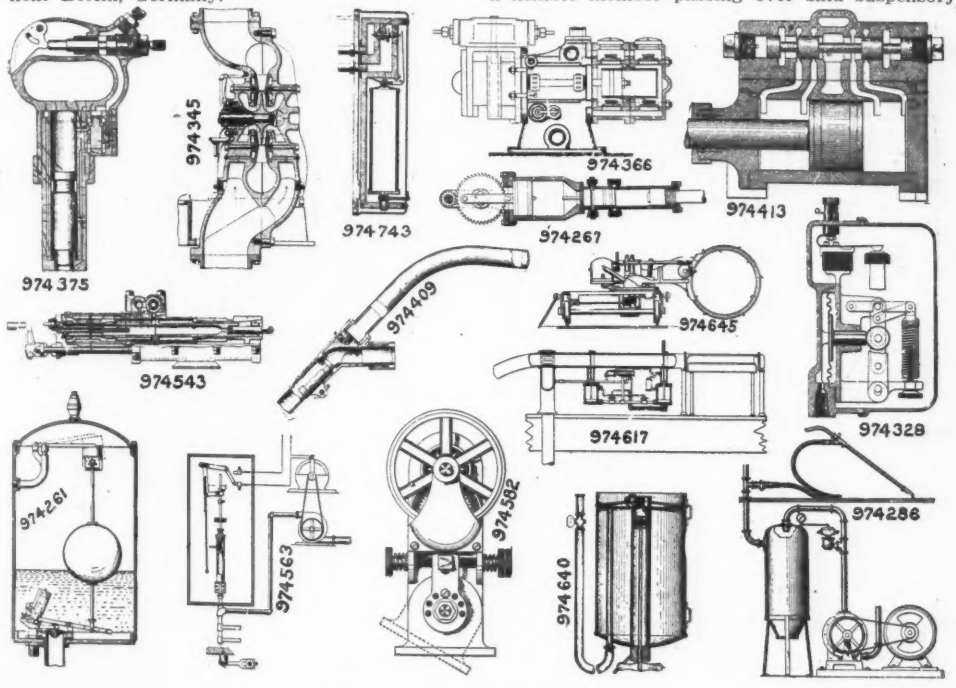
1. In combination with the valve mechanism of a fluid-pressure motor, means co-operative with the valve mechanism tending to place the mechanism in starting position, and means controlled by the pressure fluid for rendering the co-operative means inoperative.

974,913. ROTARY COMPRESSOR OR THE LIKE. WILHELM VON PITTLER, Wilmersdorf, near Berlin, Germany.

engine, said engine comprising a horizontal stationary cylinder open at both ends, oppositely acting pistons mounted in the respective ends of said cylinder, levers fulcrumed at one end and having their opposite ends connected respectively to said pistons, resilient means interposed between said levers for normally holding said pistons at their inner extremities of movement, and means for automatically feeding a percussion-powder ball into said cylinder with each reciprocation of said pistons, and means co-acting with said pistons whereby, upon each reciprocation of said pistons, air is forced into said tanks, substantially as described.

975,196. APPARATUS FOR TESTING FLYING-MACHINES AND LEARNING THE ART OF AVIATION. RICHARD ALEXANDER-KATZ, Berlin, Germany.

1. A device of the character described comprising an aerial track, a suspensory device rotarily supported by and adapted to travel on said track, a flexible member passing over said suspensory



PNEUMATIC PATENTS NOVEMBER I

974,934. METHOD OF CASTING METAL. CHARLES H. UPSON, Waterbury, Conn.

The method hereinbefore described of casting metal consisting in supplying air under pressure to the metal when pouring the same.

974,995. WIND-MOTOR. JOHN SCHIES, Anderson, Ind.

974,997. AIR-REGULATOR. WILLIAM A. SHORB and GUY R. RODGERS, Decatur, Ill.

975,028. VACUUM-CLEANER. JOHN A. FORNEY, Reading, Pa.

975,040. PROCESS FOR REMOVING OXYGEN FROM VESSELS. ROBERT HOPFELT, Cologne-Klettenberg, Germany.

Process for the elimination of oxygen from any desired containers by union of the oxygen with phosphorus, consisting in causing phosphorus-halogen gases mixed with hydrogen to ignite in the previously evacuated container.

975,136. AIR-COMPRESSOR. JAMES J. KIELY, Chicago, Ill.

1. The combination in an air compressor of an explosion engine, air tanks mounted adjacent said

device and to one end of which the flying machine or aviator may be suspended, a counterweight attached to the other end of said flexible member, and means for limiting movements of ascent and descent of said counterweight and object suspended from said member.

975,229. FLYING-MACHINE. ROSCOE C. GORE, Tecumseh, Nebr.

975,230. PNEUMATIC STACKER. JOHN HAGEN, Hopkins, Minn.

975,233. AIR-COMPRESSOR. JOHN HANNA and ALBERT HENRY HANNA, Troy, N. Y.

975,258. PNEUMATIC-CUSHION FURNITURE. WILLIAM E. KURTZ, Oakland, Cal.

975,275. INTERNAL-COMBUSTION ENGINE. GEORGE MORTIMER PERLEWITZ, Chihuahua, Mexico.

1. An internal combustion engine, comprising a casing, a power wheel mounted therein and provided with a high pressure side and a low pressure side, means for supplying air into said low pressure side, mechanism for compressing said air thus supplied into said low pressure side, an

explosion chamber connected with said high pressure side, means for conducting said air after receiving a compression into said explosion chamber, means for supplying a fuel into said explosion chamber, an igniting device for exploding a mixture of said fuel and said air under compression and allowing the gases of combustion to explode in said high pressure side, and means for conducting said gases after expansion in said high pressure side over to said low pressure side of said power wheel.

975,380. VACUUM CHURN APPARATUS. THOMAS BERNTSON, Pittsburg, Pa.

NOVEMBER 15.

975,396. VACUUM CLEANING APPARATUS. FREDERIC B. COCHRAN, New York, N. Y.

975,403. AEROPLANE. JOHN WILLIAM DUNNE, London, England.

975,435. VACUUM CLEANING APPARATUS. HERMAN G. KOTTEN, Englewood, N. J.

975,467. FLUID-PRESSURE APPLIANCE. THOMAS S. SCOTT, Pittsburg, Pa.

975,957. FRICTIONAL AIR-COMPRESSOR. CHARLES AVERY JAQUA, Portland, Ind.

975,997. CENTRIFUGAL PUMP, CONDENSER, AND COMPRESSOR. EDMUND SCOTT GUSTAVE REES, Wolverhampton, England.

976,004. COMPRESSED-AIR WATER-ELEVATOR. ERNEST C. SMITH and WILLIAM A. CRUMPACKER, Centerview, Mo.

976,081. AIR-PURIFYING APPARATUS. JOHN H. KINEALY, Ferguson, Mo.

NOVEMBER 22.

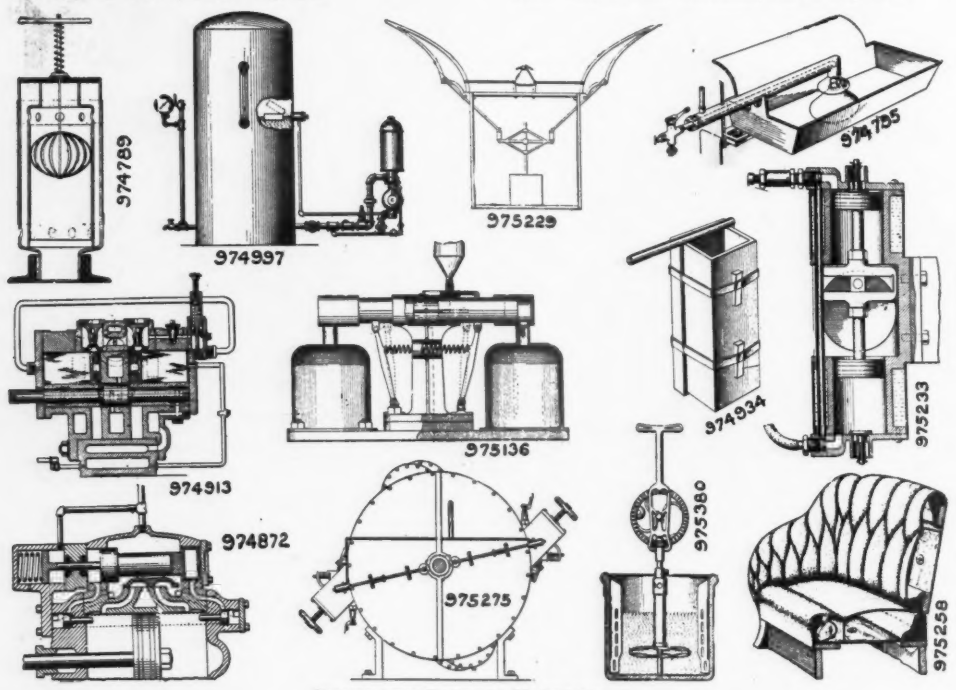
976,161. FLYING-MACHINE. SILAS H. FRENCH, Oberlin, Ohio.

976,174. STANDARDIZING DEVICE FOR GOVERNORS. GEORGE J. HENRY, JR., San Francisco, Cal.

976,224. AIR-BRAKE. AUGUSTUS A. ST. CLAIR, Indianapolis, Ind.

976,242. AQUARIUM. JOHN F. WOHLFAHRT, St. Louis, Mo.

976,268. APPARATUS FOR BURNING CRUDE OIL. ALBERT R. KUNKEL, Palestine, Tex.



PNEUMATIC PATENTS NOVEMBER 8.

975,473. AIR-PUMP. GREGORY J. SPOHRER, Franklin, Pa.

975,501. PNEUMATIC-DESPATCH APPARATUS. THOMAS BEMIS, Indianapolis, Ind.

975,532. MOTOR SUCTION-PUMP. WILLIAM H. KELLER, Philadelphia, Pa.

975,588. PNEUMATIC SYSTEM FOR AUTOMOBILES. ROBERT S. WALLACE, Forney, Tex.

975,578-9. GLASS-BLOWING MACHINE. WILLIAM DAYTON FREDERICK, Bridgeton, N. J.

975,774. TIRE-INFLATING PUMP. CHARLES LEWIS, Auburn, N. Y.

975-782. SAND-BLAST APPARATUS. WILLIAM P. MOTT, Chicago, Ill.

975,891. HAMMER-DRILL. WILLIAM PRELLWITZ, Easton, Pa.

975,903. PNEUMATIC-DESPATCH-TUBE APPARATUS. CHARLES F. STODDARD, Boston, Mass.

975,905. HAMMER-DRILL. ALBERT H. TAYLOR, Easton, Pa.

2. A crude oil burner comprising an elongated tubular mixing chamber, a nozzle for compressed air discharging into said chamber at one end, a nozzle for crude oil under pressure discharging across said air inlet, discharge nozzles for the mixed air and oil leading laterally from said chamber, and needle valves in said nozzles.

976,285. FLUID-PRESSURE-ACTUATED VISE. JOHN E. OSMER, Chicago, Ill.

976,305. MILKING MECHANISM. DAVID TOWNSEND SHARPLES, West Chester, Pa.

976,429. PNEUMATIC GUN. AXEL LINUS BLOMEN, Sundyberg, near Stockholm, Sweden.

976,458. VALVE-GEAR FOR FLUID-PRESSURE MOTORS. CHARLES HAMMEN, Chicago, Ill.

976,494. VACUUM-SWEEPER. FRANK JULIUS QUIST and MALCOLM BLANCH, Worcester, Mass.

976,556. DEVICE FOR ESTABLISHING A PULSING MOTION OF FLUID IN CONDUITS. GUSTAF DALEN, Stockholm, Sweden.

1. In pulsators for milking machines operated by pressure, the combination with a casing, of a block movable therein between two seats, two conduits opening into the casing chamber above the block, one of said conduits opening through one of said seats, a piston connected with the block and movable in a part of the casing beneath the block, a branch from one of the conduits, opening into the casing chamber beneath the piston, a transverse partition wall between the block and the piston, provided with the second seat for the block, and an outlet conduit opening in the casing chamber between the partition wall and the piston.

976,566. PNEUMATIC CLEANER. ELWOOD GROSS, WILLIAM E. GROSS and WALTER FELTER, West Pittston, Pa.

976,592. LIQUID-FUEL BURNER. BENTON MOORE, Cherryvale, Kans.

1. A liquid fuel burner comprising a pan, an air pipe discharging thereinto, an oil pipe in the air pipe, and discharging in the direction of the said chambers being provided with an upwardly opening outlet.

NOVEMBER 29.

976,840. SECTIONAL PNEUMATIC TUBE. FRANCIS R. BAYLIS, Lansing, Mich.

976,853. GOVERNING MECHANISM FOR FLUID-PRESSURE ENGINES. HERBERT H. DOW, Midland, Mich.

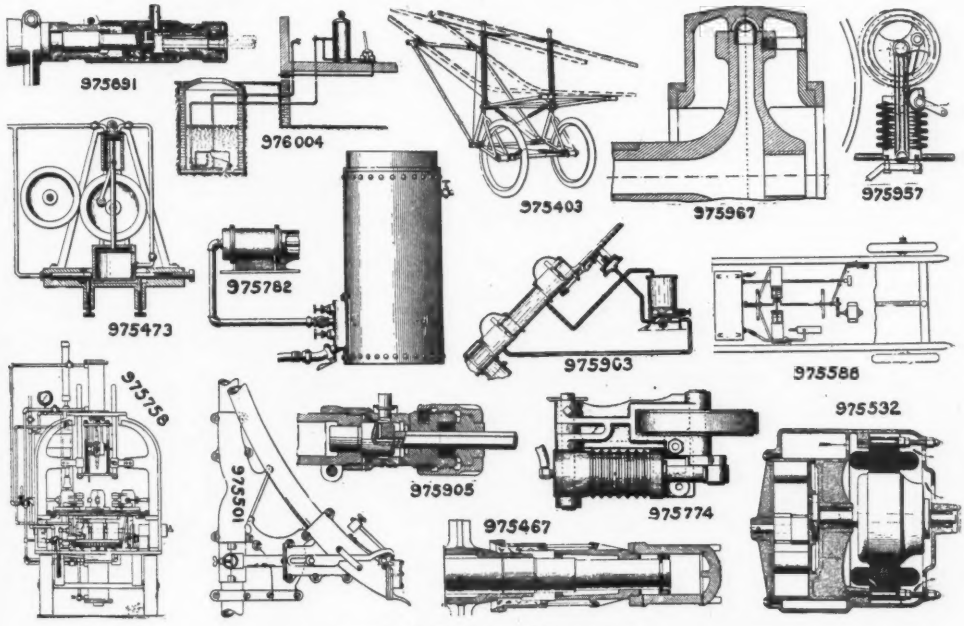
967,873. AIRSHIP. THADDEUS S. HARRIS, Modesto, Ill.

976,876. AEROPLANE. LOUIS ADOLPHE HAYOT, Beanvais, France.

976,966-7. METHOD OF HEATING AIR. GEORGE WESTINGHOUSE, Pittsburg, and ALEXANDER M. GOW, Edgewood, Park, Pa.

976,983. FLUID-PRESSURE MOTOR AND CONTROLLING MECHANISM THEREFOR. WILLIAM H. CAHAL, Chicago, Ill.

976,998. FLUID-OPERATED ROTARY-MOVEMENT-REVERSING MECHANISM. GEORGE A. FOWLER, Denver, Colo.



PNEUMATIC PATENTS NOVEMBER 15.

pan, a tube surrounding the discharge end of the oil pipe, and a steam generator located above the pan, and connected to the tube.

976,671. AIR-BLAST APPARATUS FOR COTTON-GINS. OSMON W. MCDONALD, Rising Star, Tex.

976,688. BOTTLING-MACHINE. ANDERS ANDERSEN PINDSTOFTE, Copenhagen, Denmark.

976,703. DRILLING-MACHINE. ARON G. SEBERG and EDWIN G. SEBERG, Racine, Wis.

976,744. PNEUMATIC-DESPATCH-TUBE APPARATUS. JOHN T. NEEDHAM, New York, N. Y.

976,781. APPARATUS FOR PRODUCING CARBURETED AIR. RICHARD BUSCH, Hanover, Germany.

976,818. COMPRESSED-AIR APPARATUS FOR ELEVATING LIQUIDS. LOUIS S. MATHEUS and CHARLES LEINDECKER, Lawrenceburg, Ind.

1. In an apparatus of the character described, the combination with a stand-pipe, of a compressed air inlet pipe extending into the stand-pipe, a plurality of chambers, pipes connecting said chambers in series, and a connection between the lower end of the compressed air pipe and the lowermost one of said chambers, each of

977,110. PNEUMATIC-DESPATCH-TUBE APPARATUS. JAMES G. MACLAREN, Weehawken, N. J.

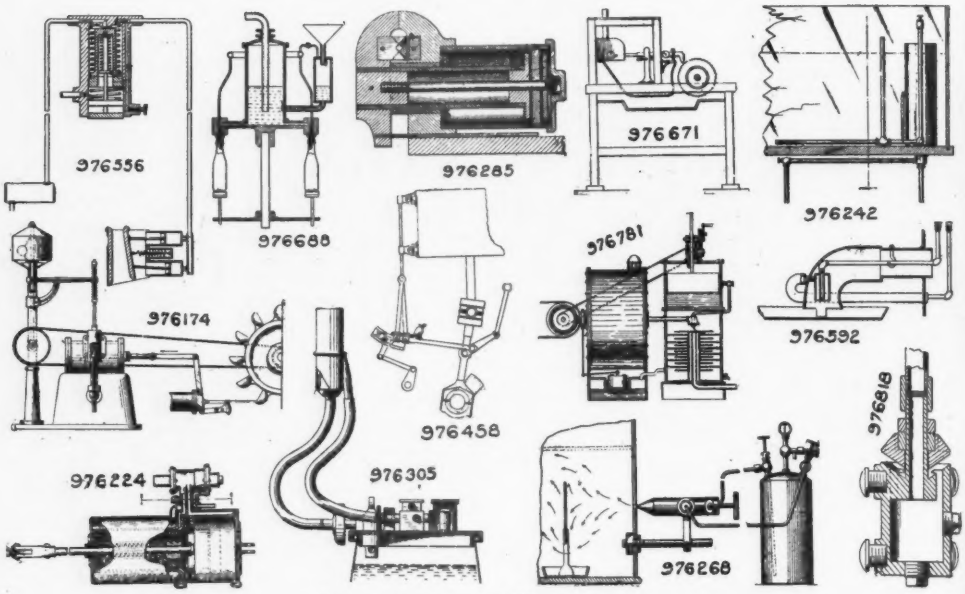
977,160. PNEUMATIC SEPARATOR. FREDERICK A. BRENNER, Milwaukee, Wis.

5. In pneumatic separators, the combination of a forwardly and backwardly reciprocating suction box provided with bottom openings, means for creating suction from said suction box, a rotatable roller located to the rear of the normal forward position of the suction box, and air blowing mechanism to the rear of the roller and constructed to direct blasts of air over the roller and toward the suction box, and thereby serve to separate or disengage surplus sheets of paper from the bottom of the suction box.

977,164. DUPLEX-PRESSURE STRAIGHT-AIR BRAKE. CHRISTOPHER P. CASS, St. Louis, Mo.

977,208. METHOD OF COMBUSTION OF OIL AND GAS MIXTURE. HUDSON MAXIM, New York, N. Y.

1. A process of the character described, consisting in superheating a moving body of com-



PNEUMATIC PATENTS NOVEMBER 22.

mingled steam and oil, introducing air into said moving body, subdividing the fluid mixture into a plurality of streams and cooling the latter in proximity to the zone of combustion.

977,274. AIR-PUMP. WILLIAM A. COOK, New York, N. Y.

977,281. AIR-BRUSH. THOMAS A. DE VILBISS, Toledo, Ohio.

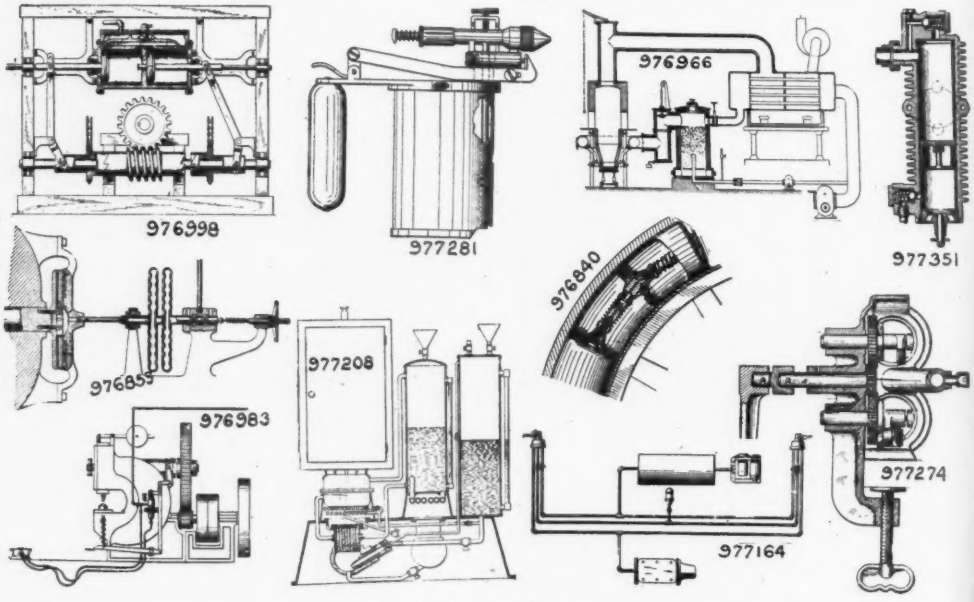
977,335-6. MEANS FOR FILTERING AIR AND PRODUCING OZONE. SAMU'L C. SHAFFNER, Chicago, Ill.

977,338. VACUUM-PUMP. ARTHUR H. SQUIER, Philadelphia, Pa.

977,351. POWER TIRE-PUMP. HAROLD D. WATERHOUSE, Wollaston, Mass.

977,377. TRIPLE AUXILIARY AIR-VALVE FOR CARBURETERS. VINCENT H. DONNELLY, HARRY B. KOESSLER and JOSEPH T. WEINZIERL, New Kensington, Pa.

977,380. VACUUM DUST-REMOVER. CHARLES B. FOSTER and WILMOT W. GLIDDEN, Oak Park, Ill.



PNEUMATIC PATENTS NOVEMBER 29.

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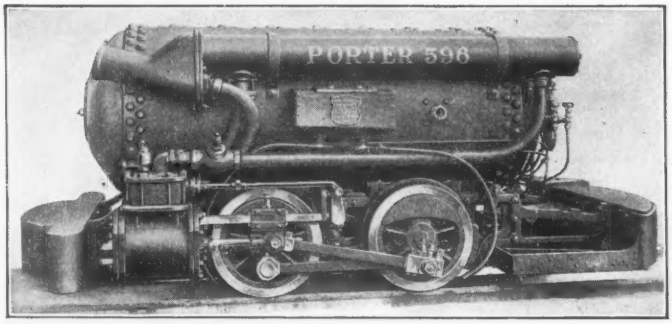

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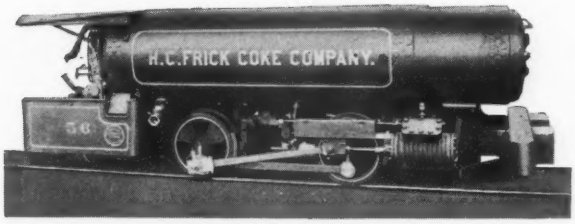

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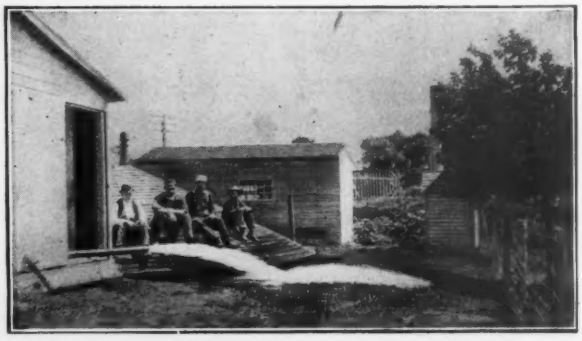

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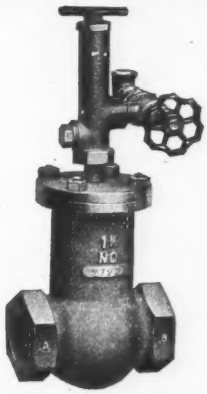

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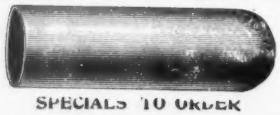
TANKS  TANKS
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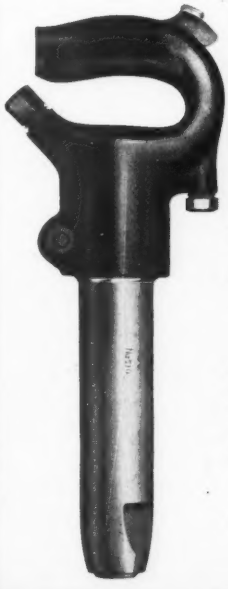

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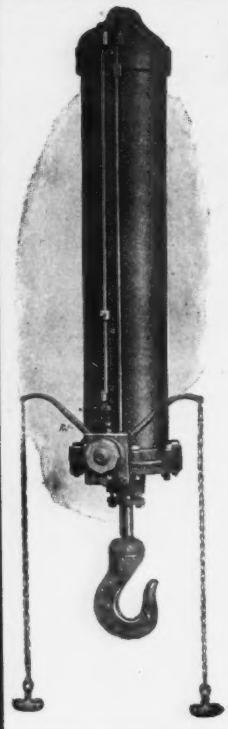

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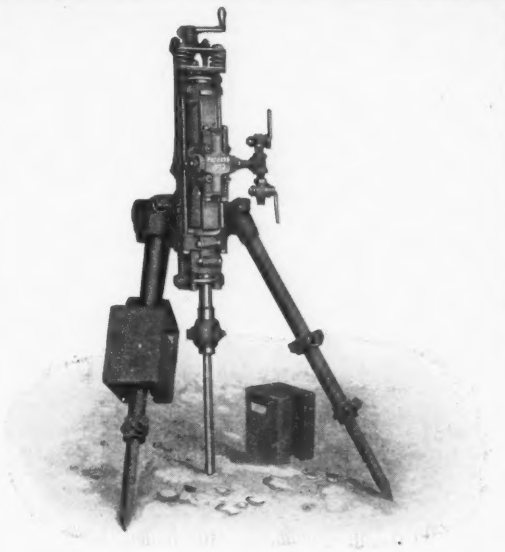

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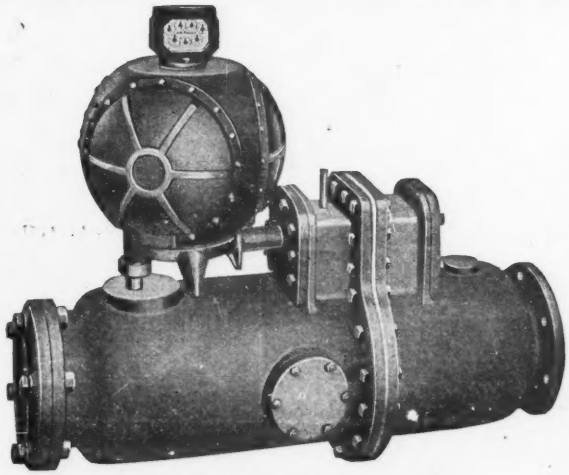

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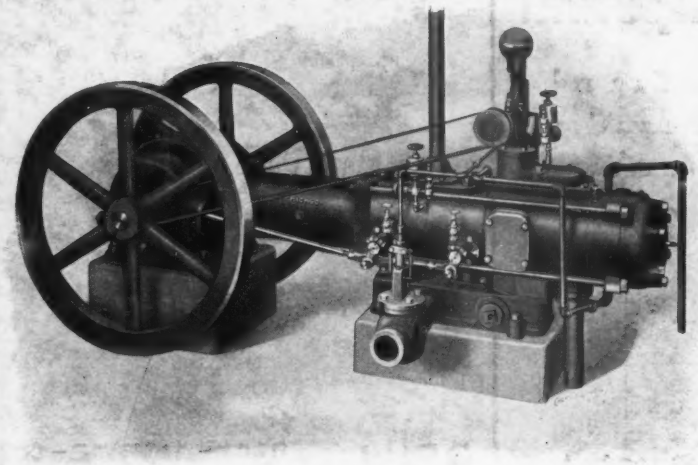

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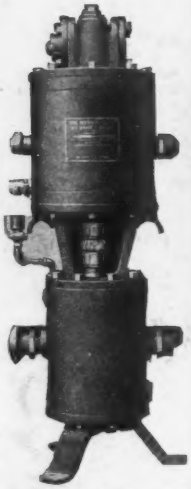

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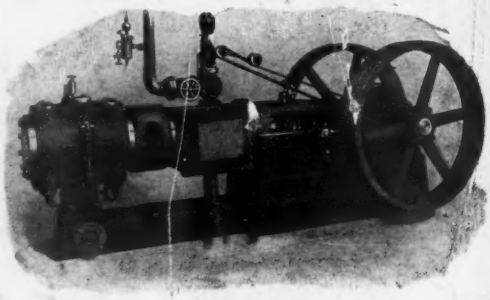

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